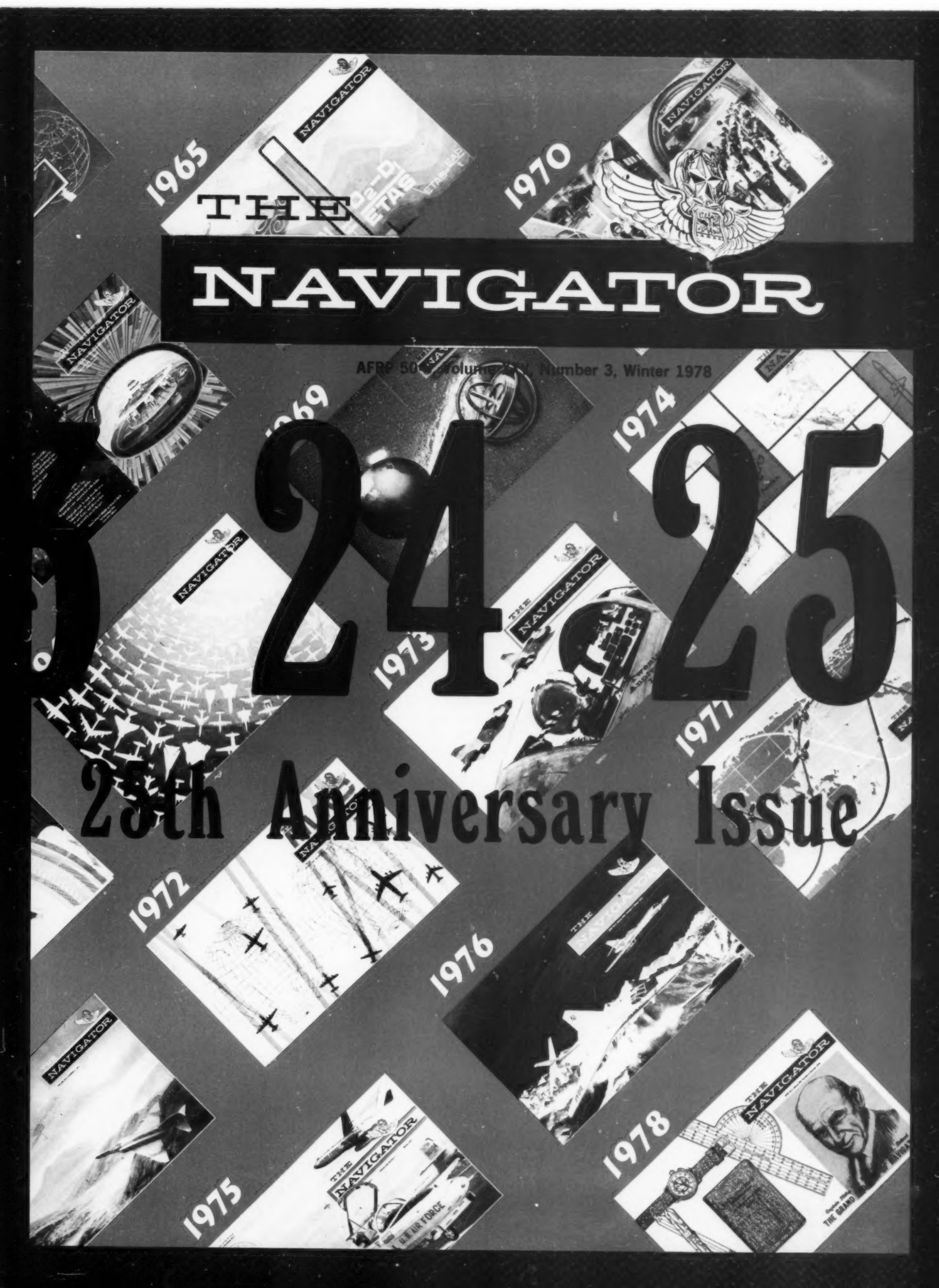
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AFRP 50-2, Volume XXV, Number 3, Winter 1978
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25th Anniversary Issue

DEPARTMENT OF THE AIR FORCE
OFFICE OF THE CHIEF OF STAFF
UNITED STATES AIR FORCE
WASHINGTON, D.C. 20330
8 SEP 1978

Captain Steven Hurwitz, USAF
Editor, THE NAVIGATOR Magazine
323d Flying Training Wing
Mather AFB, California 95655

Dear Captain Hurwitz:

Congratulations to THE NAVIGATOR for 25 years of outstanding service to the U.S. Air Force. Since its inception, THE NAVIGATOR has illuminated numerous technological advancements and procedural changes that have contributed immeasurably to the proficiency and operational effectiveness of Air Force navigators.

Additionally, your magazine's influence has enhanced the professional careers of prospective trainees and operational navigators in all U.S. military services and friendly foreign countries.

Best wishes for continued success.

Sincerely

LEW ALLEN, JR., General, USAF
Chief of Staff

NAV OF NOTE

Major General Robert E. Sadler is the only navigator to command a major air command — Air Force Communications Service. A master navigator, he is also a former member of the editorial staff of THE NAVIGATOR — from back in the days when it was called the "Aircraft Observer." We thought it would be appropriate to spotlight "one of our own" for our anniversary issue.

Commissioned at 19, as a rated navigator at Hondo AAF, General Sadler attended radar observer school at Victorville Army Air Field. He was in the first class of the Aerial Observer Bombardment (AOB) School at Mather. While attending the AOB school, he was a halfback on the Mather football team, along with many key staff members of the school. He is sure that it was "coincidental" that he was the only member of his class who remained at Mather after graduation.

"I spent my first 14 years as a working navigator," he recalls. "My tours included crew duty as a B-29 navigator and radar operator in the 715th Bomb Squadron, 509th Bomb Group; Wing Navigator for the B-29 Combat Crew School at Randolph; Editor and Editorial Director of flying manuals in Air Training Command; exchange student in the RCAF Specialist Navigation School; and Chief, Advanced Flying (Navigator) Training at the Air Force Academy."

"I really learned the navigation business while attending the postgraduate Specialist Navigation Course with the RCAF and while I was writing and editing Air Force Manuals. My first job was to make the initial revision of AFM 51-40, Air Navigation, by adding chapters on radar and polar navigation and pressure pattern flying. I couldn't have done it without a lot of help from the smart guys at Mather." Following that revision, the general helped plan, "write the book" and edit revisions to AFM 51-40 over a six-year period. He wrote "In-flight Maintenance of the APQ-24" from scratch; a similar manual on K-systems (with a lot of help from Sperry); "Air Navigation for Pilots"; and was responsible for editing a host of other manuals covering a wide range of flying subjects. During this time, General Sadler was also on the original staff of THE NAVIGATOR magazine, which was then the "Aircraft Observer."

Entering AFIT at the University of Colorado, his aspirations were to get into the development of bombing and navigation systems. "I thought I had it made when I was lined up to be the Bomb-Nav Weapon Systems Project Officer on the B-70." But those systems didn't make it on the B-70. So, when he graduated with a bachelor of science degree in Electrical Engineering, he was assigned to the Air Force Communications Service — a lucky break. This initial assignment led to several key command and staff positions — from action officer to Deputy Director, Command Control and Communication in the Air Staff, DCS Communications Electronics for 7th Air Force, Commander of the 1964th Communications Group in Vietnam, Director J-6 for the Joint Chiefs of Staff, Director Plans and Programs for the Defense Communications Agency, Commander Northern Communications Area, Vice Commander and Commander of AFCS.

As the Commander of AFCS, General Sadler is responsible for communications, air traffic control, and common user data automation processing activities throughout the Air Force. His command spans the globe; and nearly 50,000 people at 500 units and 400 locations wear the command patch which vividly depicts the command's mission motto — "Providing the Reins of Command." He is also responsible for training more than 15,000 Air National Guard and Air Force Reserve personnel who stand ready to augment the command with a full-range of skills that are tested throughout every year.

With such a widespread command, General Sadler is on the road 30 to 40% of the time. He believes that the only way you can run a large organization like AFCS is to "get out among them" and see what's going on. His philosophy of command is that his people really don't work for him, they work for the people with the mission — that's what counts. He believes that communications is a good second career for navigators — there are four "navigator" generals in the communications business and two of his area commanders and many of his group commanders and key staff members are navigators.

"Readiness is the common denominator of all of our mission activities," he says. "Our job is to provide the Air Force with a means of command and control and support of the forces, and to work towards doing it better tomorrow. I tell my people to focus on getting that job done. Our rewards and our prestige depend on how well we do the job, not how loudly."

Looking back at his career he says, "The smartest things I ever did was to join the Air Force and stay in — the Air Force educated me and gave me more breaks and opportunities than I deserved." He credits his experiences as a navigator for learning the need for precision and relying on his judgment and his training as a cadet and at Mather for teaching the meaning of being competitive and for the discipline it takes to get the job done. "Yes," he reminisces, "in those days at Mather, student officers marched to class, had Saturday parades and standby inspections."

"I had two strokes of luck," he adds, "getting assigned to AFCS and getting through Navigation School at Hondo. Night celestial was challenging with an A-10 sextant in an AT-7 wallowing through the air at 8,000 feet over west Texas, and it took a lot of luck."

He recently visited the 509th at Pease AFB, and while in the FB-111 simulator, mused, "It is so easy nowadays that it's almost like cheating." But was quick to add that it is very difficult when the right gear isn't working and it still takes a smart operator to put the crosshairs on the aiming point. To those who worry about what automation is going to do to the navigator, he points out that, "Elmer Sperry invented the autopilot 70 years ago and we still have a left seat and a right seat."

General Sadler is married to Kathleen I. English of Manchester, England. They have six children. His decorations include the Defense Superior Service Medal with one oak leaf cluster, the Legion of Merit with two oak leaf clusters, the Meritorious Service Medal, and the Air Force Outstanding Unit Award, with the "V" device and an oak leaf cluster.

DEPARTMENT OF THE AIR FORCE

THE NAVIGATOR

AFRP 50-3, Volume XXV, Number 3, Winter 1978
Distribution: One copy per two navigators.

SECRETARY OF THE AIR FORCE
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Published triannually with funds approved by Headquarters, United States Air Force. Distributed through the Air Force Publication Distribution Center in accordance with Air Force Regulation 7-1.

Manuscript contributions are welcomed, as are comments and criticisms. Contact the Editor at the address below or at (916) 364-2138 or AUTOVON 828-2138 before extracting from or reprinting material. Opinions expressed by individual contributors do not necessarily reflect the official viewpoint of the Department of the Air Force.

Address manuscripts to Editor, THE NAVIGATOR Magazine, 323 FTW/DOTN, Building 3860, Mather AFB CA 95655. Address subscriptions to Superintendent of Documents, GPO, Washington DC 20402: yearly $3.00 domestic, $3.75 foreign; single copy $1.00. Air Force Recurring Periodical 50-3.

Authority to publish this periodical automatically expires on 26 January 1980 unless its continuance is authorized by the approving authority prior to that date.

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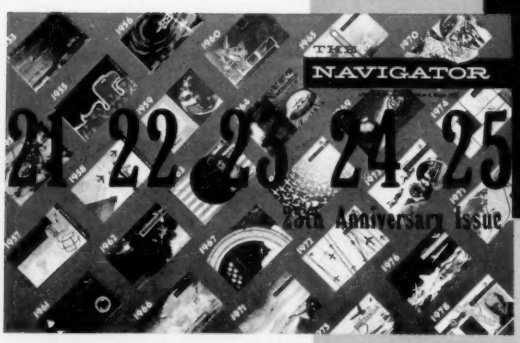


Covers from each of THE NAVIGATOR'S twenty-five years are pictured on the cover. The critical role of navigation in the Air Force mission echoes strongly in a two part story starting in this issue (page 22). Navigation in the future is the subject of The Joint Chiefs of Staff Master Navigation Plan (page 9).

25th ANNIVERSARY ISSUE

A STERN INTERCEPT TECHNIQUE

Captain John Q. JORDAN
58 TTS/W
Luke AFB, AZ

The stern conversion is one of the most important intercepts used by the fighter aircrew. This intercept puts the fighter aircrew at six o'clock to counter any bogey or bandit offensive maneuvers. The stern conversion gives us tactical advantage and is the direct result of the weapons system operator and pilot working together using crew coordination.

Many stern intercept techniques are taught throughout our tactical air forces. These include the Sync-Z turn, the GCI based technique taught at Tyndall, and the overtake technique. The overtake technique usually is taught at F-4 RTU. Each technique has its advantages depending on what is best suited to the WSO. While the overtake method is generally accepted as the standard for F-4 crew members, I would like to suggest the 40° cold of CATA at 25 nm technique as a viable alternative.

The overtake technique consists of locking-on, mentally centering the computer dot to find the hot and cold sides and collision antenna train angle (CATA), noticing the overtake, and then applying the displacement and pursuit guides.

DISPLACEMENT GUIDE	PURSUIT GUIDE
900 KTS Vc — 40° Cold	700 — 7 nm
800 KTS Vc — 20° Cold	600 — 6 nm
700 KTS Vc — 10° Hot	500 — 5 nm
Less than 700 KTS Vc — CATA	350 — 4 nm
	250 — 3 nm
	Throttle Advantage — 2 nm

Also, this technique assumes that the interceptor has a 5:4 speed advantage over the target. I believe that all WSOs are familiar with this technique and I will not discuss that aspect further.

I now will examine some discrepancies with this technique. A premise of this technique is: if you have a 5:4 speed ratio and get the target to your nose so as to have 700 K Vc at 7 nm, then, with the 500:400 KTAS ratio, you will make the 600 K Vc at 6 nm, etc. In reality, this premise is not always valid. Pure pursuit runs the fighter very hot. If we meet 700 K Vc at 7 nm and continue to hold the target on our nose, we will hit 670 K Vc at 6 nm and 500 K Vc will not be seen until 3 miles. Rollout will occur at slightly less than 1 mile.

The displacement guide also has disadvantages. It does not consider range. Generally, an initial displacement of 8-10 nm is necessary in order to convert to the bogey's stern from a 180° heading crossing angle set-up without bleeding away airspeed at too great a rate. Given the same geometry we must take different actions for different ranges. In both Figures 1 and 2 the

Figure 1

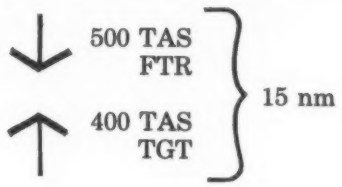
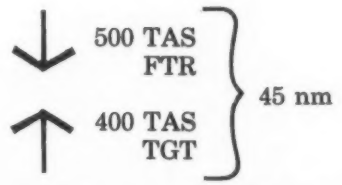


Figure 2



nose is hot, either side is cold and 900 K Vc exists. In Figure 1, a hard turn to put the target at 50° cold would accomplish the displacement needed. In Figure 2, it would take only a check turn to place the target 20° cold. These figures are not exact but are rounded off to the next higher 5° and are figured at the 500 KTAS to 400 KTAS speed ratio. Putting the target 40° on the cold side would not accomplish our objective in either case. In Figure 3, the fighter lies 60° off the target's nose. With the range 30 nm, the fighter has 25-26 nm lateral separation. With a 500:400 KTAS ratio, overtake is 554 K Vc. According to the

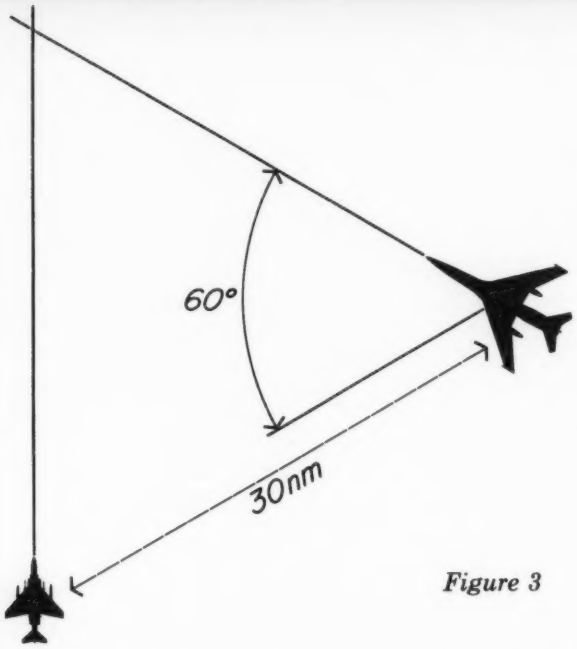


Figure 3

displacement guide, we would maintain a collision course and then break it at approximately 6 miles range. If airspeeds are changed to 650:520 KTAS (5:4 speed ratio still) then Vc will be 720 K. The displacement guide tells us to bring the target to 10° hot. As the nose is turned toward the target, Vc will increase rapidly. The target would then have to be placed on the cold side of the scope. Applying the displacement guide and placing the target cold, the fighter will fall to a low aspect and a long tail chase. For the low aspect setup, as in Figure 3, we obviously need to pull some lead and the displacement guide will produce this lead in all cases.

From these examples, it appears that using overtake to figure displacement is not always the only answer. Furthermore, the guide is valid only for a 5:4 speed ratio where the target has 400 KTAS and the interceptor has 500 KTAS. This method also does not promote student knowledge of intercept geometry. I would therefore like to suggest another method for accomplishing stern conversions. This method uses an angular intercept geometric relationship and helps build student awareness of the intercept problem (three dimension thought pattern).

The 40° cold of CATA at 25 nm technique is an easily used alternative and requires fewer computations. Captain Charles Sallee, Luke AFB, developed this technique in the fall of 1977. The technique is simple to learn, and easy to apply and remember. This system does not require a lock-on and works well with all aspects and contact ranges. It is based on a 5:4 speed ratio, but varying the ratio down to co-speed yields much less error than any other technique I have encountered. This system was not developed by using a large computer, but by using a programmable calculator and empirical data and then developing rules-of-thumb from the observations and calculations. A pursuit curve was developed that changes from 40° cold of CATA at 25 nm to 55° cold of CATA at the 10 nm range. Beyond 25 nm, maintain a collision course and break collision early enough to arrive at 40° cold of CATA at 25 nm. Therefore, this system seems to work well out to any realistic contact range.

A detailed discussion of this system appears appropriate at this point. To hold a target the pursuit angle is 40° cold of CATA at 25 nm. For every mile less than 25 nm, add a degree to the pursuit curve. Thus, if you intercept the pursuit guide at 15 nm, you must hold the target 50° cold of CATA. Lead must also be applied, so you must lead the target and get him 40° cold of CATA by 25 nm or meet another checkpoint. This lead is called "will be range."

Azimuth to hold target for a stern conversion:

40° cold of CATA at 25 nm
45° cold of CATA at 20 nm
50° cold of CATA at 15 nm
55° cold of CATA at 10 nm

"Will be range" means to allow for the few miles of target travel during fighter reaction, and round down to the nearest 5 nm. For example, if range is 30 nm when the target is contacted, figure that the target will be at 25 nm by the time the desired azimuth is computed and the target is placed there. If the pick-up is at 26 nm, then the target will be at 20 nm by the time the desired azimuth is achieved.

Let us now apply the 40° cold of CATA at 25 nm technique. First find CATA. Let us say it is 10° left in this example. Now find 40° cold of CATA. That is, from 10° left to 30° right is 40° cold of the 10° left CATA. Now we note that the range is 24 nm. "Will be range" is called 20 nm, 5 nm shorter than 25 nm so we hard turn and place the target at 30°+5°=35° on the right side of the scope and fly to hold him there. We now have intercepted the pursuit curve.

Unless the target is on our nose, at some point we will have to break the pursuit curve. If we maintain lead pursuit, we cannot get to the target's six o'clock. Lag pursuit will get us to the target's six o'clock but with a heading difference. A technique that works well is to use twice the lag

or lead angle (the angle the target is off our nose) as the point at which to bring the target to our nose. For example, we are holding the target at 15° (hot or cold) off our nose. We will keep the target there until heading crossing angle (HCA) =30° and then bring the target to our nose. To carry this example further, if we are holding the target at 15° on the cold side and the target is heading 180° with us in a left-hand turn, then we will bring him to the nose as we pass a heading of 210°. We now have a rule-of-thumb for breaking our pursuit curve.

The step-by-step procedures are:
(1) Find CATA.
(2) Note present range and determine the "will be range."
(3) Determine the pursuit curve to be intersected at the "will be range," i.e., 40° cold of CATA at 25 nm, 45° cold of CATA at 20 nm, etc.
(4) Turn to put the target on the pursuit curve desired.
(5) While maintaining the target on the pursuit curve, determine when to bring the target to the nose by using the formula: HCA=2x number of degrees the target is off the fighter's nose.

This technique does have disadvantages. It requires a good CATA and, thus, good target heading information. If the fighter can get target heading from some reliable source, such as GCI, then CATA can be figured with a high degree of accuracy. If we must estimate target heading, and our estimate is inaccurate due to jamming or some other complication, then our estimated CATA can be in error so that the intercept is way off. The requirement for an accurate target heading and computation of CATA are the major drawbacks to this system.

The advantages of this system outweigh the disadvantages. For one thing, the 40° cold of CATA at 25 nm technique is easy to remember with no complicated formulas or mental gymnastics needed. All that need be remembered is to place the target 40° cold of CATA at 25 nm or add one degree more cold of CATA for each nautical mile less than 25 nm. Another advantage is that this guide applies to all reasonable pick-up ranges. As I said in the opening paragraphs, the overtake technique did not work well much inside 20 nm. Finally, this system works very well with RTU students and those Phantom WSO fliers that run intercepts very rarely. This technique helps the young WSO build an understanding of the three dimensional geometry involved in stern conversions. This technique also keeps the young student away from rote memorization of steps and makes him a critical thinker during the intercept. This technique warrants consideration in the tactical environment — it's quick and easy and frees the WSO to check six or find another bandit to kill. Give it a try!

In 1970, Capt Jordan graduated from Fitchburg State College and then OTS. After UNT in 1972, he flew the EB-66 over North Vietnam and Route Pack Six while participating in the Linebacker operations. Returning from SEA, Capt Jordan completed F-4 checkout at Luke AFB before assignment to Spangdahlem AB. He now is an instructor at Luke AFB.

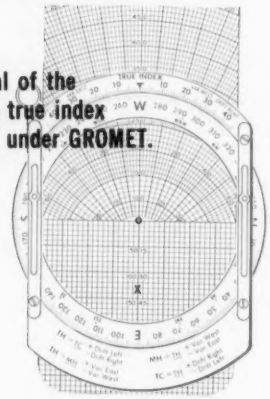
MONITORING APPROACHES

Second Lieutenant Joseph A. DRAGO
384 AREFW
McConnell AFB, KS

In most aircraft, the navigator has information available that can make penetration, approach and landing more precise and safe. This article is a compilation of some techniques I have found useful during those critical stages of flight — as the ground gets closer. There are a couple of things you can do to make your equipment, especially the radar, work for you during transition. For starters, plot the approach paths and holding patterns for your base and several primary alternates on an ONC/TPC scale chart. A few "canned" radar fixes at key turn points will help you keep the aircraft in the holding airspace or on course. It is also helpful to annotate the initial headings for an ARDA on the chart. And finally, remember to figure lead points. The following rules may help you with radius of turn computations: radius of 90° turn (nm) equals: (1) for 30° of bank, indicated mach times ten, minus two; or, (2) one-half of one percent of ground speed

for standard rate turns. Remember the "1° equals 1 nm at 60 nm" rule for converting radials into miles when figuring lead points on arcing approaches.

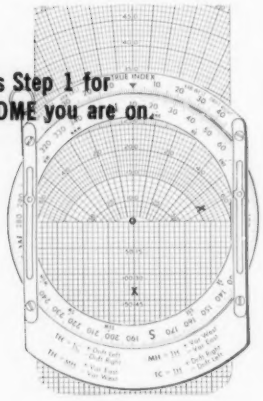
Since the pilots will be flying TACAN fix-to-fix, you should be able to use your computer to give them precise headings to the fix. The computer procedure in Figure 1 will help.



STEP 1
Set MAG radial of the IAF under the true index and plot DME under GROMET.

RADIAL OF IAF

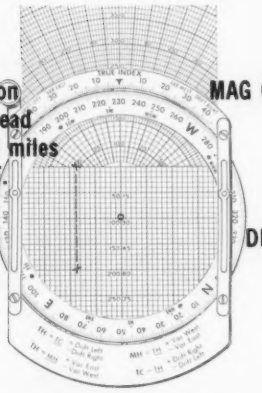
DME OF IAF
40 nm



STEP 2
Do the same as Step 1 for the radial and DME you are on.

YOUR RADIAL

YOUR DME
40 nm



STEP 3
Align the plots on a vertical line, read MAG course and miles to go to the IAF.

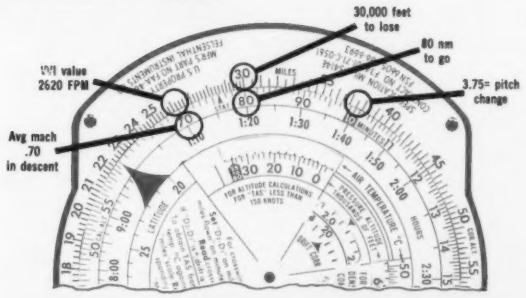
MAG COURSE TO IAF

DISTANCE TO IAF
61 nm

FIX TO FIX COMPUTER
Figure 1

On your high altitude chart, plot descent points to aid in flying a smooth enroute descent and to ensure that frequently issued altitude restrictions are met. Figure 2 shows a convenient computer method for determining descent rate and degrees of pitch change from average mach, distance to go, and altitude to lose.

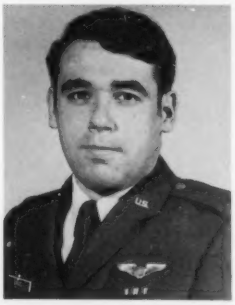
1. Set thousands of feet to lose on the outer scale over miles to go on the inner scale.
2. Read the VVI value on the outer scale above the average mach number during descent.
3. Read the degrees of pitch change from level flight on the outer scale over the 10



COMPUTER VVI VALUE/PITCH CHANGE METHOD
Figure 2

As you depart holding and begin the final approach phase, you should be mindful of a few considerations. If you are cleared for the approach while under radar vectors, consider two things: (1) you are not automatically cleared to hold or maneuver, so know where you are in the approach profile and what action is required; and, (2) for descent purposes, you are considered on course when within 2.5° of the course, on an intercept heading, and not planning to be outside 2.5° of the course again.

When cleared to begin descent on a PAR final, an initial descent can be figured using the computer. Set the glidescope angle in the upper portion of the drift correction window and read the VVI value on the outer scale across from the average ground speed.



Lt Drago graduated from Holy Cross College, Worcester, Massachusetts, in 1976. Following UNT, he was a CCTS distinguished graduate in 1977. Lt Drago now serves with the 384th Air Refueling Wing at McConnell AFB.

The Joint Chiefs of Staff
Master Navigation Plan

Colonel Stephen W. GILBERT
OUSDRE/CS
The Pentagon
Washington, DC

Defense of the United States involves military commitments that span the globe. These commitments require the ability to conduct military operations at any time, any place, and in all weather conditions. Fundamental to this is the ability to navigate a wide variety of weapon platforms on land, sea, and in the air. In addition to this fundamental need to navigate, which is not unique to the military, there are even more important and stringent requirements for precise position determination to enhance our ability to deliver weapons and support other critical and unique military missions.

Recognizing that the diverse positioning and navigation requirements of the military could lead to a proliferation of systems and equipment, each designed to meet specific military requirements, the Joint Chiefs of Staff (JCS) have developed a Master Navigation Plan. This plan addresses military positioning and navigation (POS/NAV) requirements, with heavy emphasis on systems that provide large-area coverage and those generally designed for joint-Service use.

The title, "Master Navigation Plan," may be somewhat deceptive since: (1) it encompasses more than basic navigation, extending into Mapping, Charting, and Geodesy, and requirements for Precise Time and Time Interval; (2) it is not truly a "Master" plan since it does not deal in-depth with systems and equipments that provide basic point-to-point or localized navigation services; and (3) it is more than a plan—embracing a total philosophy of long-range positioning and navigation system development and acquisition to meet stated military requirements. It does, however, provide a concise and coordinated approach to an extremely complex problem used within the Department of Defense in support of planning, programming, budgeting, and implementation of POS/NAV systems.

The JCS Master Navigation Plan builds upon plans of the individual Services and Department of Defense Agencies. Each Service or Agency develops its baseline mix of navigation systems and equipment that allows each weapon system to operate at peak efficiency in its military role while retaining the ability to operate in accordance with national and international civil rules and regulations. This distinction is important in recognizing the role of the JCS Master Navigation Plan. That is, the military must navigate and position itself in two basic frameworks, civil and military. The JCS Master Navigation Plan deals primarily with the latter framework.

The JCS plan addresses and lists validated military POS/NAV requirements, with emphasis, as stated earlier, on systems with large-area coverage and joint-Service application. By involving all Department of Defense activities, the plan establishes a framework for value judgments concerning critical issues, preventing piecemeal solutions and ensuring that today's decisions don't jeopardize long-term growth in navigation system capabilities and availability.

The JCS plan recognizes the interface with related civil plans such as the National Plan for Navigation. NATO military navigation requirements are also considered from the standpoint of compatibility and interoperability. Other related interfaces are considered in the JCS plan, such as Air Traffic Control (both in the military theater and in the National Airspace System), Air Defense, Command and Control, the impact on Mapping, Charting, and Geodesy and the worldwide transfer of Precise Time and Time Interval.

The task of developing, deploying, and maintaining a minimum number of POS/NAV systems which respond to the maximum number of user needs is of major proportions. The following list of characteristics, considered "essential" for an "ideal" worldwide POS/NAV system reflect the magnitude of this task:

Worldwide Coverage
User Passive
Use can be denied to unauthorized users
No saturation limit
Resistance to Meaconing, Interference Jamming, and Intrusion (MIJI)
Resistance to natural disturbance and hostile attack
Effective, real-time response
Available for combined military operations with our allies
Provide common grid to all users
Position accuracy not degraded by changes in altitude
Accurate during high-energy maneuvers
Maintainable at the operating level
Self-contained
Continuous availability of fix information

These characteristics are representative of most of our military missions. They highlight one of our most perplexing problems: How to develop a system which responds to all user needs—one that can be used by aircraft, submarines, land vehicles, and even by satellites—one that would be usable to us in war or peace, yet not available to an enemy. Clearly, there is no single system that can exhibit all of the above characteristics. In fact, even with the current mix of specialized systems and equipments we fall short of meeting all of these characteristics.

With the exception of the Navy Navigation Satellite System (TRANSIT) and the growing number of Inertial Navigation Systems, our present inventory of long-range navigation systems is still landlocked. We have three LORAN configurations and the OMEGA system.

a. LORAN A has run its course as a military aid. During the past 30 years, this low frequency system has been a primary and reliable system for military use. However, the need for higher accuracy has driven us to the LORAN C configuration.

b. LORAN C is also a low frequency system which provides improved accuracy in the Northern hemisphere. The Department of Defense plans to continue using this system as one of the primary sources of precise and general all-weather navigation aids until a suitable substitute is deployed.

c. LORAN C/D is the mobile tactical system being deployed by the Air Force. High accuracy navigation information can be provided within 48 hours in contingency situations where existing navigation aids may be either nonexistent or denied.

d. OMEGA is a very low frequency navigation system that provides continuous, worldwide position fixes. Although OMEGA is a high quality navigation aid, its military use is limited since it does not provide sufficient accuracy for most military requirements and its availability during wartime is subject to continued operation on foreign soil.

The Navy Navigation Satellite System (TRANSIT) provides positioning updates to over 175 Navy platforms and some 14 other nations also use its services. Although not continuous, TRANSIT has successfully supported widespread use by many ships. Its main constraint is the long time between fixes.

As one might expect, the main thrust of our long-range military system planning is toward satellites. Examination of the list of essential characteristics for a worldwide positioning and navigation system leads, almost intuitively, to the conclusion that a combination of an advanced navigation satellite system with self-contained and/or special-purpose navigation systems will be most effective. The improved coverage and accuracy, and minimum dependence of ground based systems located outside of the United States, are obvious advantages.

a. The NAVSTAR Global Positioning System, currently in the Concept Validation phase of development, is being designed to satisfy the majority of our long-range positioning and navigation requirements. This system, when fully deployed in the mid-1980s, is expected to provide three-dimensional positioning accuracy better than 10 meters and to exhibit most of the essential characteristics previously listed. Assuming successful deployment of this system, the JCS Master Navigation Plan calls for a controlled phase-out of military use of LORAN and TRANSIT and continued but limited use of OMEGA as a backup worldwide navigation aid.

b. The Joint Tactical Information Distribution System (JTIDS) will provide secure digital communications between force elements and will allow those same force elements to determine their relative positions.

c. The future ground tactical system is the Position Location Reporting System (PLRS) being developed by the Army and Marine Corps for use in the tactical environment. This special purpose system will be used to coordinate air support, amphibious operations, and ground maneuvering forces. Full operation is scheduled for the mid-1980s.

d. Self-contained Inertial and Doppler Navigation Systems are important components of our worldwide strategic forces, and in some areas provide the only reliable means of navigation. As such, they will be retained.

With this mix of future systems, we look forward to higher accuracy, smaller and more reliable packaging, development of hybrid combinations of navigation sensors, and more efficient operation in our global mission. This is the key element of the JCS Master Navigation Plan. With this mix of future systems and equipment, all attainable within the state-of-the-art, we will achieve the goals of reduced redundancy, minimization of mission unique systems, and significantly enhanced military effectiveness.

Col Gilbert holds a BS degree in Electrical Engineering from the University of Illinois and a MS degree in Aeronautics/Astronautics from the University of Colorado. Since 1973, he has been involved with development of the NAVSTAR Global Positioning System; first as Deputy Program Manager, NAVSTAR Joint Program Office, and then as the NAVSTAR Program Monitor, HQ USAF. Col Gilbert is the focal point for Positioning and Navigation Systems, Office of the Under Secretary of Defense for Research and Engineering.

where will we be without TACAN ?

Captain Michael J. SCHULTZ
HQ AFSC/SDED
Andrews AFB, MD

The focal point for navigation within the federal government until recently has been Office of Telecommunications Policy (OTP) within the Executive Office of the President. Since 1972, OTP has focused on radio navigation aids. According to data developed by OTP, we spend $1 billion per year in procurement and maintenance of 38 separate and overlapping navigation systems — recall just how long the phasing out of LORAN A has taken. Navigation aids traditionally have been developed in response to defense requirements. Over the period of their use, however, others have discovered their usefulness. In the case of LORAN A, for example, inexpensive receivers became standard equipment for small commercial fishing craft. The hue and cry was deafening when that industry was faced with the costs of conversion to a new system.

Be that as it may, OTP believes that a reduction from 38 to 14 federally supported navigation aids will result in a savings of $25 billion dollars. LORAN A, VOR-DME, Omega, Long Range Radar, Airport Surveillance Radar, Precision Approach Radar, and the Instrument Landing System should be memories by the beginning of the twenty-first century. This list reflects solely the navaids commonly used by the Air Force. Others, including many used by Navy surface forces, also will be replaced.

Paramount to the accomplishment of this transformation is the commercialization of the NAVSTAR Ground Positioning Satellite. NAVSTAR plays a role in national security by providing accuracy in positioning far greater than is commonly required. This is fine; on the other hand, it is necessary to deny access to this system to any potential enemy. The solution to this dilemma is the development of parallel standards of user access. I don't want to concern you here with the intricacies of NAVSTAR (Editor's Note: see THE NAVIGATOR, Winter 1977 for discussion of NAVSTAR), but it is possible to build satellite receivers of varying sophistication. Fortunately, the simpler and less expensive receiver will satisfy commercial requirements. Strategic users will need high power signal processing electronics to extract greater accuracy, for which DOD alone has the capability.

In addition to NAVSTAR, we can anticipate significant improvement in approach and landing aids, specifically the Microwave Landing

System (MLS), DOD, DOT and NASA, throughout the 1970s, have been working on a replacement for ILS, a landing aid whose limitations were apparent during World War II. MLS, using modern technological advances which permit higher frequencies — hence shorter wavelengths and commensurately smaller antennae — is in its development stage now and already exhibits an accuracy ten times greater than the present standard. The advantage of MLS, however, is not limited to increased accuracy. The entire logic of precision approaches will be changed. ILS guidance is provided along runway extended centerline ± 3°, requiring straight-in approach. Special MLS STARs for the FAA Experimental Airfield at Atlantic City call for circling and S-turns on final. MLS eventually will enable curved and steep approaches that satisfy the demands of noise abatement and population/terrain avoidance.

The cockpit will not escape unscathed. TACAN-based navigation aids such as the horizontal situation indicator will be of little use in the post-TACAN world. Microprocessors will be needed which instantaneously convert satellite-generated positions into lat/long and heading/distance to go. Three-D approaches, moreover, require a revolution in Flight Director Systems. According to the Air Force Flight Dynamics Laboratory:

> "The increasing use of digital techniques in aircraft systems, digital flight controls and guidance systems are the most likely to succeed methods of implementing the complex precision approach capability that fully exploits the volume of MLS guidance coverage."

Now that we've seen the "blue skies" thinking, it is important to note where we stand today. OTP and its successor, the National Telecommunications and Information Administration within the Department of Commerce, is the driving force for change. Perhaps the prime technical factor, one which compliments the economic advantage, is that radio-navigation frequency bands are becoming more and more crowded, to the point where some current navaid or another will need to be eliminated in order to accommodate new.

It is the economic factor, however, that predominates. As we approach the twenty-first century, in technology as in politics, smaller just may be better. Certainly the emphasis already is on economy, in addition to reliability and maintainability. We can hardly justify the proposed 24 NAVSTAR satellites without demonstrating a broader mandate—that the system is commercially desirable as well. The General Accounting Office, too, demands that the future not be delayed, calling for shutdown of the VORTAC navaid network by 1990-1991. While such rapid change would be difficult, we will undoubtedly be spurred on by increasing upkeep costs of duplicate systems. Air Route Traffic Control will have to be reprogrammed to handle direct routing from takeoff to touchdown, a feature hopefully already within the system's capability.

Greater resistance to change is being met by those favoring MLS. While U.S. officials are pleased with the recent ICAO decision to validate the U.S.-Australian Time Reference Scanning Beam MLS, no one seems too eager to lead the development of the sophisticated cockpit instrument new generation approaches will demand. Much reluctance will come from pilots loath to relinquish their "hands on responsibility" for the job of "flight systems monitor." I suspect that Flight Director compatible microwave approaches will be developed and that only a new generation of aircraft will have the "systems" capability for advanced approaches. ICAO has recommended the continued use of ILS till 1995 and may well continue it for 10 years beyond. With bold nations leading the way, we shall require dual compatible Flight Directors for some time to come.

In short, the future for navigation suggests evolution rather than revolution. As in most other areas of technology, however, the pace of evolution quickens yearly. What will appear merely evolutionary to navigation planners and designers may well appear as quantum jumps in accuracy and efficiency to the general public. In the cockpit, the aircrew member will be freed from dreary, repetitive mechanical tasks to concentrate on mission accomplishment.

A graduate of Kenyon College, Capt Schultz completed UNT in 1971 and then served as a navigator/weapon system officer in the EC-121, F-4, T-43, and C-130 aircraft. He left active duty in 1975, and works for the Navy as an electronics engineer. In the Air Force Reserve, Capt Schultz is a Mobility Augmentee at HQ AFSC, Andrews AFB.

Major Terrence M. MURPHY
4444 OPS/OTD
Luke AFB, AZ

Captain James T. BRIDGES
4444 OPS/OTD
Luke AFB AZ

Navigators, their training, and their career potential as rated officers in the USAF are at the crossroads. We should concern ourselves about who and what we are training, and to what end. As the possibility arises of replacing the traditional navigator with dual inertial systems in C-141s, is it possible that we have not been as progressive as we could have been concerning the way we train? Perhaps if we looked at the development of new systems as a challenge and broke the mold on training the traditional navigator, we could become a dynamic and indispensable element in the future of the USAF.

The Tactical Air Command, long the bastion of the single seat fighter pilot, opened its doors to navigators/weapon system officers (WSOs) in the late '60s in the F-4 and F-111 aircraft (not to mention the F-105 EWOs and RF-4C WSOs). Two of the three USAF aces to emerge from the SEA conflict were WSOs. This is not to say that all was roses for the WSO; there were mistakes made in training and in providing opportunities for positions of responsibility. In recent years, however, TAC recognized that significant deficiencies existed in WSO training. The TAC/DO established a WSO ad hoc committee to examine ATC, USN, and USAF training programs and provide solutions for the young WSO coping with the tactical environment.

The solution to the problem of these training deficiencies was to significantly change the WSO's continuum of training. ATC and TAC have worked together to develop the first block in the training structure (UNT). This has manifested itself in a curriculum which includes tailored WSO tasks in the academic, simulator, and flying environments (T-37). This program is awaiting final implementation, but will serve as a basis for training problems of the F-4G, EF-111, and new digital F-4E.

After UNT, the WSO candidate enters the second block of the structured WSO progression, T-38 Lead-In Training, where development of tactical skills begins. Then, F-4 academic and simulator training are designed to support demanding tasks in the tactical flying arena. The flying portion of the lead-in syllabus specifically tasks the WSO not only in the areas of tactical lookout responsibilities and UHF radio communications, but also in directing tactical formations, initial moves, and defensive counters. Additionally, mission planning skills are honed to equip the individual to deal with exacting instrument techniques and procedures. The traditional navigator skills of celestial and grid are of relatively little value to the WSO who is beginning to become a *systems* officer.

Now begins the third block of instruction toward combat capability; the dedicated WSO F-4 RTU. In the past, the WSO was paired with a pilot counterpart in an F-4 RTU which fostered a "second class" syndrome and contributed to ineffective WSO training. TAC recognized that with the changing role of the F-4, a strong and knowledgeable WSO must emerge from the training pipeline. Recently in "TAC Attack" (March 1978) Lt Billy Barbour noted: "WSOs will find themselves all but maxed out unless they are prepared to navigate, recall headings, check six, have two or three sets of pop and release parameters memorized, operate the WRCS and TACAN, talk on the radio, and copy down TAC

Guest Cartoonist

Lieutenant Colonel Stanley E. VAN HORN

instructions, not to mention figuring out the run-in time, the pop point, and then directing the pilot to the egress heading. Meanwhile...the pilot is flying and chewing gum the whole time but not at the same time!" Perhaps now you are beginning to see the importance of a well trained and competent WSO in the tactical arena. TAC's dedicated WSO syllabus provides the intensive and demanding training required to equip the WSO with the attitude and skills necessary to fly and fight as an equal to the pilot in today's high threat environment. So what is the "Tactical Environment?" It's 100 feet AGL, 500+ knots, MIGs, ZSU-23-4, SA-6s, and the bomb on the target ± 10 meters and get home!

So how do we get there from here? We develop a WSO with the attitude, experience, and credibility to perform demanding tasks in a high stress situation. Attitude is an essential requirement for combat capability, regardless of which seat or cockpit is being discussed. There are no second class citizens in combat! How do you develop credibility? First, take pride in yourself as an aviator, take pride in being a WSO, and demonstrate the desire to be the best WSO in the squadron!

The WSO must be an expert in the performance of a myriad of tasks in an avionics intensive environment. This environment includes the AN/ARN/101 Digital Modular Avionics System, Pave Tack Infrared Laser Designator, Digital Scan Converter Radar, ALR46A Radar Warning Receiver, Pave Phantom (LORAN) Navigation and Bombing System, and the Infrared Maverick Missile (Air-to-Surface) System. These, plus the traditional tasks of air-to-air intercepts (tactical) and nuclear strike, should give you an idea of how important the training of the WSO really is. This student should be able to at least leap medium sized buildings upon graduation from F-4 RTU and taller ones within three months of getting to an operational unit.

Realistically, the WSO who strives to become an expert contributes to the advancement of our capabilities and force readiness. It is our job to train toward that end. We want you to realize that even with the new single seat fighters (F-15, F-16, and A-10) the F-4 is alive and kicking in TAC. The need for aggressive and competent WSOs is evident. We are getting more selective in our training programs and are more demanding of our WSOs. Only those who want to be here will remain.

We've laid out a pretty one-sided argument in defining the needs of tactical training, but if we are to train as we fight, we must intensify the goals of training the individual to meet the threat. Check Six.

Editor's Note: This discussion of WSO training parallels some forthcoming changes in UNT. More about these changes (called specialized training) in our next edition.

Maj Murphy, a graduate of Ohio State University, completed navigator and F-4 training. He was then assigned to Udorn RTAFB and flew 104 missions over North Vietnam. Next came assignment to RAF Bentwaters, followed by Luke AFB. Maj Murphy presently is the F-4 OTD Assistant Team Chief at Luke AFB.

Captain Bridges graduated from Delta State University, Cleveland, Ohio. After navigator and F-4 training, he served with the 8 TFW at Ubon RTAFB, followed by assignment to Seymour-Johnson AFB. Capt Bridges is a member of the F-4 OTD Team, Luke AFB.

NAVIGRAMS

NAV COMMANDERS:

Lt Col John R. O'Rosky, the new commander of the 756th Tactical Airlift Squadron (AFRES) and Col Jere J. Danaher, the previous commander, hold the same aeronautical rating - master navigator. Both gentlemen have had extensive flying experience as well as numerous staff positions within the squadron at Andrews AFB. *Editor's Note: For an interesting discussion of navigator command see POINT COUNTER POINT in the Jan-Feb '78 issue of Air University Review.*

USAFA NAV SYMPOSIUM:

The US Air Force Academy Aviation Science Division recently hosted a Navigator Symposium to bring the major commands up to date on developments in the navigator career field. Twenty delegates representing the CONUS based commands, MPC, the 323 FTW at Mather AFB, AFRES, and the ANG exchanged information concerning weapon systems development, mission changes, and navigator opportunities throughout the Air Force. Other topics of interest included the Global Positioning System, the Institute of Navigation, and the new "Tailored Nav Program" being instituted at UNT. The results of the Symposium were very positive, and future agenda items were discussed. The Aviation Science Division would like to host similar annual gatherings. If you have pertinent items you would like to see on next year's agenda, please contact Captain Ben Pittman at AUTOVON 259-3790.

EYEBALL NAVIGATION:

Marvin Creamer and his son, Kurt, recently completed an Atlantic crossing in their 30-foot ketch. Their navigation was adequate--landfall was close enough to make it to their destination at Cape May, New Jersey. But perhaps their navigation was better than just adequate--considering that they used no nav aids, not even a compass. Instead, the Creamers navigated by estimating heading and latitude by simply looking at the stars. A recently retired geography professor and veteran of three Atlantic crossings, Creamer had theorized that the Irish and Norse sailors of pre-Columbus days must have been able to navigate without navigational tools. After much practice, on land, Professor Creamer was able to prove with his journey that such navigation is possible. And for you more meticulous types, the answer is no; Professor Creamer did not apply P&N or Coriolis.

UNT AWARD WINNERS:

The ATC Commander's Trophy is presented to the most outstanding graduate of each UNT class. We are happy to introduce a new feature in THE NAVIGATOR to provide you with information about these exceptionally well qualified new navigators. To start with, in this issue, we will list all the winners for FY78:

RANK/NAME	CLASS	HOMETOWN	ACFT	SQUADRON/BASE
2d Lt Mary K. Higgins	78-01	Hometown, IL	KC-135	380 AREFS/Plattsburgh AFB
2d Lt James L. Pasquino	78-02	Summerville, SC	B-52	46 BMS/Grand Forks AFB
2d Lt Jeffrey A. Blohm	78-03	Denver, CO	C-130	1 SOS/PACAF
2d 2Lt Kurt F. Haden	78-04	Long Beach, CA	F-4	31 TFW/Homestead AFB
2d Lt Stephen Marchitelli	78-05	Lakewood, CA	B-52	337 BMS/Dyess AFB
Capt Russell C. Lowmiller	78-06	Williamsport, PA	F-111	27 TFW/Cannon AFB

(continued on page 18)

The First Atlantic Crossing

Captain K. N. GIFFARD
323 FTW/DOTN
Mather AFB, CA

It's good to occasionally reflect upon the accomplishments of those who preceded us in the conquest of the skies. Almost sixty years ago, in June of 1919, two British World War I aviators—John Alcock, as pilot, and Arthur Whitten-Brown, as navigator—urged a struggling Vickers-Vimy bomber airborne from a converted cricket field near St. Johns, Newfoundland, with Europe their destination.

Lest we dismiss their success as luck, a brief look at the flight will show that it indeed took luck, but more so, it took an enthusiasm for flight and adventure, determination, physical stamina, and considerable heroism to conquer the North Atlantic.

Their radio was lost on takeoff when the generator propeller departed the airplane.

Their mariner's sextant, used with a carpenter's level to get an artificial horizon, was adequate—when the skies allowed. Brown had to be quick, once shooting Polaris and Vega at night through a momentary opening in the clouds, and shooting the sun, when they briefly managed to clear the fog covering most of their route.

They entered a spin at 10,000 feet—and broke into the clear, partially inverted, less than 100 [illegible] Alcock recovered the Vickers—b[illegible] evidenced their closeness to disaster.

Six times Brown had to climb onto [illegible] against the wind and snow—chipping [illegible] engine air intakes and instruments. Failure meant certain death for the two aviators.

Dinner was their only reprieve from the harshness of the flight—complete with ale and a jug of Irish coffee one of the ground crew had thoughtfully packed.

Success came after 16 hours with the Vickers landing in an Irish peat bog. All Britain cheered their triumph, knighthood followed, but then the glory was too short—John Alcock was killed less than six months later in a flying accident.

NAVIGRAMS

(continued from page 15)

2d Lt Phillip R. Hitch	78-07	Abilene, TX	F-111	48 TFW/USAFE
2d Lt David M. Edgington	78-08	Fairborn, OH	F-111	20 TFW/USAFE
2d Lt Paul E. Pirog	78-09	Novi, MI	B-52	9 BMS/Carswell AFB
2d Lt Douglas P. Miller	78-10	Syracuse, NY	F-111	366 TFW/Mt Home AFB
2d Lt Darryl F. Gross	78-11	E. Greenwich, RI	F-111	27 TFW/Cannon AFB
2d Lt William S. Clendenen	78-12	Los Osos, CA	F-111	366 TFW/Mt Home AFB
2d Lt John C. Armstrong	78-13	Youngstown, OH	C-130	1 SOS/PACAF
2d Lt Mark O. Eshleman	78-14	Stockton, IL	C-130	36 TAS/McChord AFB
2d Lt Ronald J. Kurjanowicz	78-15	Queens, NY	F-111	366 TFW/Mt Home AFB
2d Lt Charles G. Duke III	78-16	Fayetteville, NC	F-111	27 TFW/Cannon AFB
2d Lt John K. Larned	78-17	Laurel, MT	F-111	366 TFW/Mt Home AFB
2d Lt Andrew L. Traywick	78-18	Mt Dora, FL	RF-4	363 TRW/Shaw AFB
2d Lt James A. Patterson	78-19	Austin, TX	F-111	366 TFW/Mt Home AFB
2d Lt Richard S. Adams	78-20	San Antonio, TX	F-111	48 TFW/USAFE
2d Lt Joseph B. Baillargeon, Jr.	78-21	Tupper Lake, NY	-----	453 FTS/Mather AFB (EWT)
2d Lt Marc C. Allee	78-22	Coventry, CT	F-111	20 TFW/USAFE

2d Lt Douglas W. Hale

The Daughters of the American Colonists Annual Award was initially established for the first UNT class to graduate from Mather AFB on 6 May 1966. The award, presented to the number two ranking officer in each class, consisted of an engraved silver serving tray. In 1975, the Daughters of the American Colonists expressed a desire to create a national award for the most outstanding honor graduate each year. ATC approved the new award, "Air Training Command Navigator Graduate of the Year." The award consists of an Omega megaquartz watch and a silver serving tray.

The 1976 winner was 2d Lt John M. Delaney, whose initial flying assignment was F-4s with the 56th TFW at MacDill AFB.

For 1977, 2d Lt Douglas W. Hale was selected as the most outstanding of 618 graduates. Lt Hale, a Distinguished Graduate of ROTC from the University of Tennessee, is an FB-111 navigator with the 528th BMS at Plattsburgh AFB.

WHO'S LOST?:

Many answers to "Lost" (see opposite page) contained incisive comments, but the most interesting was 1st Lt John Cirafici's (a reservist from Brooklyn, NY) opinion about the navigation of our lost and found crew: "The crew was most fortunate for their timely rescue. Parched Isla Espanola, besides lacking in inhabitants, has practically no rainfall to speak of--not to mention frequent daytime temperatures in excess of 100°F. One must ponder why the navigator--following the crew's transfer to San Cristobal--felt compelled to resolve celestially his position. The fisherman had accommodatingly taken them to within a very short (walking) distance of Puerto Baquerizo (the capital) where a small Ecuadoran military base is located and, more importantly, a wireless telegraph station. The crew could have easily - I'm sure - wired headquarters with the good news and - if necessary - conducted the nav's FEB by telegraph."

WORDGRAM

This wordgram has 53 scrambled navigational terms.
The words are up, down, sideways, reversed, and diagonal.

Air	Distance	Jet	Rhumb Line
AIREP	Diurnal	Log	Sextant
Airspace	Doppler	LOP	Star
Angle	Drift	Loran	Sun
ARC	Error	Map	Tacan
Aries	Fix	Moon	Temp
Azimuth	GEOREF	Nautical Mile	Time
Celestial	GHA	Nutation	Weather
Chart	Great Circle	Parallax	Zenith
Compass	Greenwich	Position	Z-marker
Computer	Grid	PPI	Zulu
Diego Garcia	Gyro	Radar	
Dead Reckoning	Heading	Radio	
Declination	Hertz	Range	

WORDGRAM SOLUTION
ON PAGE 30

D	E	A	D	R	E	C	K	O	N	I	N	G	R	N	U	S
Z	R	C	L	O	G	E	D	O	P	P	L	E	R	Z	G	E
A	A	H	D	I	E	G	O	G	A	R	C	I	A	M	R	X
L	D	A	I	L	O	P	O	D	R	I	F	T	D	A	E	T
T	I	R	U	Z	R	M	R	L	A	I	S	O	A	R	A	A
I	O	T	R	A	E	I	F	I	L	L	A	D	T	R	K	T	N
T	E	S	N	A	F	N	R	I	A	U	P	O	A	E	C	T
U	W	G	A	T	H	S	I	H	X	Z	R	I	R	R	I	Q
D	E	A	L	L	P	G	S	T	U	B	I	H	C	U	R	U
E	A	R	N	A	O	A	Y	L	H	M	T	M	O	A	C	P
R	T	J	C	I	S	R	U	R	T	R	B	A	U	D	L	L
N	H	E	O	R	I	I	A	M	O	O	N	L	C	T	E	A
O	E	T	M	E	T	E	A	N	G	L	E	T	I	A	H	I
I	R	I	P	P	I	S	H	E	A	D	I	N	G	N	N	T
T	T	M	U	P	O	G	R	E	E	N	W	I	C	H	E	S
A	Z	E	T	I	N	D	I	S	T	A	N	C	E	P	T	E
T	E	D	E	C	L	I	N	A	T	I	O	N	A	V	A	L
U	A	R	R	N	A	U	T	I	C	A	L	M	I	L	E	E
N	A	I	R	S	P	E	E	D	X	S	S	A	P	M	O	C

FOUND

On a flight from Hickam to the Canal Zone, you become temporarily disoriented. With fuel running low, you find an island on the radar scope. A heading is given to the pilot, a beach is spotted, and a good crash landing is accomplished on the beach. Now that everyone on board is safe, as the navigator you must determine which part of terra firma you have found. The stars are out so the problem should be easy. You have all your navigational equipment. The sextant averager is broken, but you can still take instantaneous shots. Through the clouds you find three bodies and make these observations.

GMT (1 Jan 78)	HO	
05h53m31s	35°50.1′	Menkar
06h04m10s	38°26.0′	Canopus
06h19m18s	42°18.2′	The brightest star in Leo or a planet.

Your signal fire is spotted by a local fisherman who offers to take the crew to an inhabited island. So, with your crew on board and the sails set, you fall asleep. Six hours later you are awakened by your host and deposited on a second island. It's shooting time again! You observe the sun at the appropriate time spacing to provide the best "cuts." At the following times you obtain these altitudes:

GMT (1 Jan 78)	SUN HO
15h03m41s	41°28.7′
18h02m15s	67°57.9′
21h07m38s	39°50.1′

What was your position after you crash landed and where are you now! Name the islands and the coordinates to the nearest nautical mile.

	Longitude	Latitude
Island 1	_____	_____
Island 2	_____	_____

Of the many entries in the LOST contest, reprinted in the left column, all but a few were judged close enough to be considered FOUND. Congratulations to all those Magellans who correctly (within 2 nm) identified the answers as:

Isla Espanola

01.21 South
89.42 West

Isla San Christobal

00.56 South
89.34 West

From the correct entries, we drew the three lucky winners of the DR kits:

Major John C. Stafford
Kulis ANG Base
Alaskan Air National Guard

Captain John S. Hebert
Ellsworth AFB
4th Airborne Command and Control Squadron

Staff Sergeant Edward J. Delehant III
MCAS El Toro
VMGR-352

Congratulations to all of you who correctly solved the problem. The next issue should satisfy those who asked for more such features. We'll have a real brainteaser in the spring issue. For practice, you can work on the wordgram above.

BUSY OBSERVER 1

First Lieutenant Milton NIELSEN
9 BMS
Carswell AFB, TX

Busy Observer I is the nickname for Strategic Air Command missions flown in support of ocean surveillance and reconnaissance. Aircrews are tasked to locate, identify, and photograph a U.S. Navy ship in a pre-identified search area. These areas are in the Gulf of Mexico, the Atlantic or the Pacific. This article describes the mission preparation and profile used by D model B52 crews of the 7th Bomb Wing, Carswell AFB, TX. Procedures are somewhat different in other wings, but this article will convey the flavor of this new B52 task. Busy Observer I missions usually are seven to ten hours in duration and may require air refueling. These missions require one aircraft; however, two aircraft training missions may be flown at the wing commander's discretion or when directed by higher headquarters.

Aircrews involved in Busy Observer require supplemental training and aircraft outfitted with equipment not carried on most B-52 training sorties. Intelligence Division, Tactical Communications Branch, Bombing Navigation Branch, and Maintenance personnel train the aircrews and prepare the aircraft prior to the mission as well as work with the crew in postflight and debriefing activities. Training is accomplished during the first of two mission planning days, the second day being reserved for standard crew mission planning.

All crews identified for Busy Observer training sorties attend naval ship recognition films and briefings, and must review *Missions and Characteristics of U.S. Navy Ships and Aircraft.* These briefings are conducted by intelligence personnel. Radar navigators and navigators also attend vertical camera briefings by the Bombing and Navigation Branch.

Copilots and gunners attend 35mm handheld camera briefings conducted by intelligence personnel. Electronic Warfare Officers are briefed by tactical communications personnel on message formats, coding, and required communications. They are also briefed on the anticipated operating frequency of the objective. Crews must attend briefings on formal Rules of Engagement (ROE) and on activities inside the search area. The ROE are established in part by International Law, Strategic Air Command, and the U.S. Navy and are contained in SAC OPLAN 28-76.

Ground support personnel prepare the aircraft with additional equipment. Camera maintenance uploads a K-17 or K-38 camera for vertical pictures. Additional O-15 radar camera film is also onloaded. The crew is provided with two 35mm cameras with telephoto lenses, and a tape recorder is wired into the interphone system for recordings while in the search area.

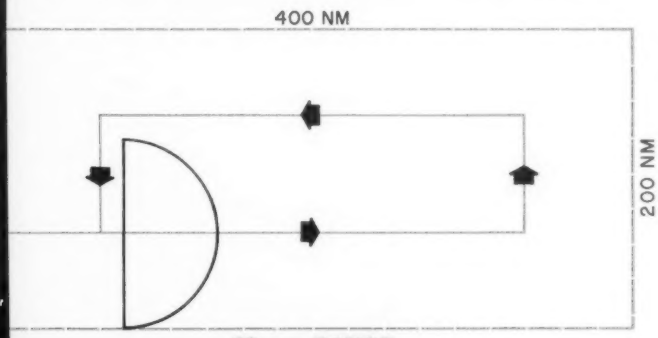
Mission planning for Busy Observer training sorties is different from other sorties. Wing Current Operations supplies the preliminary planning information, such as the air refueling track, the coordinates of the search area, and the time to operate in the search area. The navigator uses this information to determine takeoff and air refueling control times based on the time to operate in the search area. Once completed, the navigator provides Current Operations with the requested takeoff time and ARCT. Current Operations then coordinates with the controlling agencies and secures the requested times and tanker support.

The navigator must also compute appropriate ADIZ penetration data used in filing an ICAO flight plan. Other basic mission paperwork remains the same since as much additional crew training as possible is accomplished on returning from the search area.

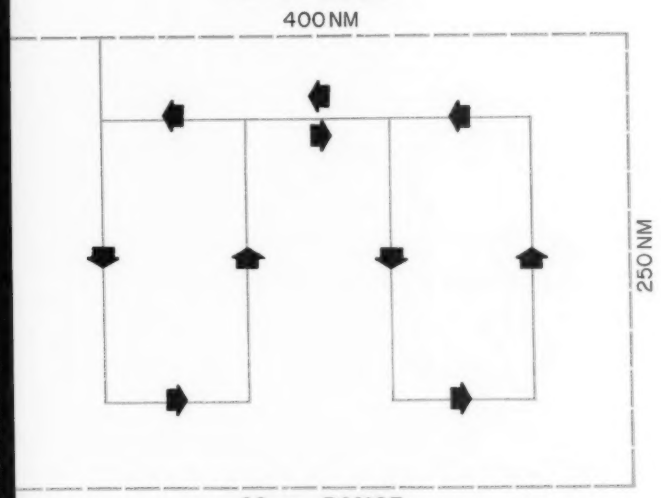
A specified series of activities occurs when the aircraft is inside the search area. Specific search patterns are used, briefed contact procedures are accomplished, and, finally, a Recognition Identification Maneuver (RIG) is used to give the aircrew increased visibility for positive

identification and a chance to photograph the vessel. These activities must be conducted within the guidelines of the formal ROE. The search patterns used are relative to the size of the search area declared by the Navy as the most probable position of the objective.

The aircrew will institute a search pattern allowing for a minimum of 10 nautical miles overlap of radar returns. Some basic patterns are:



60 nm RANGE

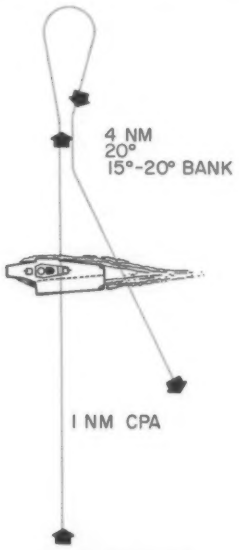


60 nm RANGE

SEARCH PATTERNS

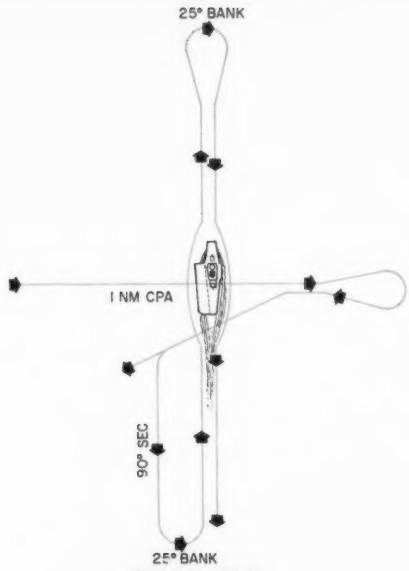
The search area is adjusted to remain clear of restricted areas, terminal control areas, international boundries, and air traffic routes. Aircraft search at a preplanned altitude between 15,000′ MSL and FL 250, and fly a TAS of best endurance plus 10 for the altitude flown. Usually 15,000′ allows for good radar returns. The aircraft flies centerline of the planned search pattern until contact is made with a vessel believed to be the objective. Initial contact may be made by either the Electronic Warfare Officer or the Radar Navigator. If the EWO makes initial contact he will give the RN a general heading and range. The RN then uses this data to find the objective on the radar scope. He then directs the aircraft to the target. Upon initial contact, the crew descends to 500′ below base altitude for the airspace, or 2,000 AGL and reduces airspeed to 240 KIAS. The aircraft then overflies the objective and accomplishes vertical photography with a K-17 or K-38 camera. A RIG maneuver will then be accomplished except if the vessel is positively identified as other than the briefed objective.

The RIG is accomplished in the following way. After crossing the vessel perpendicular to its track at 2,000′ AGL the aircraft executes a 180° turn, rolling out, headed broadside to the vessel. At 4 nm, the aircraft turns 20° off heading at 15° to 25° of bank, passing approximately 1 nm off the stern, completing the quick RIG maneuver.



QUICK RIG

If the crew now determines that the vessel in question is not the objective, the aircraft climbs to search altitude and returns to centerline. If another suspect vessel is contacted close enough to make the climb unprofitable, the aircraft remains at RIG altitude. When it is determined that the vessel in question is the objective by completing the previously described "quick RIG," the crew expands the quick RIG into a full RIG. After passing 1 nm past the stern, the aircraft executes a turn to move aft of the ship. At 90 seconds the aircraft turns back toward the stern of the ship, passing along the left side at 1 nm range. The aircraft proceeds past the bow on the same heading as the vessel until a 180° right turn may be executed. The aircraft will then pass on the right side of the vessel.

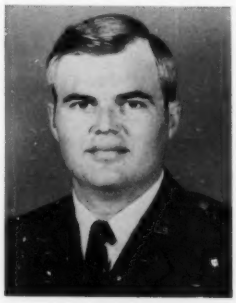


FULL RIG

During the full RIG maneuver the gunner and copilot take as many 35mm photographs as possible. If no photographs are made, a second RIG will be accomplished. Meanwhile, the navigator establishes the exact position of the ship and records its course and speed as well as the altitude and range of aircraft at initial contact. This data is given to the Electronic Warfare Officer for coding and transmission.

Upon return to home base, the aircrew attends special intelligence debriefings as well as the normal maintenance and operations debriefings. The intelligence personnel attempt to find information which will enable future crews to fly a Busy Observer training sortie more effectively, with a quicker grasp of the task to be performed and the method for completion.

The Busy Observer I training mission is another development in the broadening uses of the B-52. It enables crews to tackle a new kind of problem, and furnishes positive results of the crew's efforts. Participation in Busy Observer missions can easily be the most stimulating of present specialty training missions.



Lt Nielsen graduated from Texas A&M University with a BS degree in Political Science and a MA degree in Public Administration. He completed UNT and NBT in October 1976, followed by CCTS at Carswell AFB. Lt Nielsen is assigned to the 9th Bomb Sq, Carswell AFB.

BOMBER NAVIGATION

Mr Norman W. EMMOTT
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Rexdale, Ontario, Canada

Navigation is an art and a science inherited, by those who fly, from those who sail the seas. It is fascinating, and sometimes even glamorous, but it is intricate and demanding. At sea, the bones of wrecked ships testify to the consequences of lack of skill in it, and in the air it levies penalties for incapacity which are not less severe. Indeed, during the Hitler years, poor navigation came perilously close to losing a war.

When World War II broke out in 1939, there were two diametrically opposed theories of using airpower. One of them, the prime exponent of which was the Royal Air Force, saw aircraft as totally independent weapons, able to fight their own private war. The other school, which included Germany, France, and Russia, considered aircraft to be nothing more than another weapon, best used to support the traditional arms. The Luftwaffe, in particular, used its planes for the first two years of war as flying artillery, with its fighters devoted to making the skies safe for the Stukas and Heinkels that in turn supported the army directly,

largely in helping prepare for tank and infantry assaults. An inordinate amount of Luftwaffe resources was devoted in attacking tanks, ground fortifications, and enemy troops in the field. It is sigificant that one of Hitler's most-decorated airmen, Hans Rudel, gained his fame by attacking tanks.

Neither the Germans nor the Russians put much stock in strategic bombing. Although they killed 60,000 British during the 1940-41 blitz, the Germans never put a four-engined aircraft into service against British cities, and after 1942, their strategic bombing efforts were desultory. The Russians devoted practically all their aerial efforts to tactical targets, scarcely touching German cities with their bombs until they came into the actual combat zone.

On the other hand, the Royal Air Force (including the Dominion air forces) believed in strategic bombing with religious fervor. After Dunkirk, when the only offensive action that Britain could take was by bombing, questioning its efficacy was almost heresy. The US Army Air Forces joined them in believing that no sacrifice necessary to put bombers over the Reich was too great, no price too high to pay. Yet, when the US Strategic Bombing Commission studied the effect of the Allied air offensive against Germany, it found that on balance it had been unsuccessful. For at least the first four years of the war, the strategic assault had been run at a loss — each bombing attack cost the Allies more in fuel and aircraft, effort and lives than the damage it inflicted on Germany.

Part of the reason for the initial belief in the efficacy of strategic bombing lay in a gross overestimate of the damage bombs can do. At the beginning of the war, it was believed that the lethal pressure against human targets was about five pounds per square inch; experiments carried out in late 1941 by Professor Sir Solly Zukerman and his Oxford team proved the lethal pressure to be 400 to 500 pounds per square inch.

Such overestimates led the Royal Air Force to dispatch a force of aircraft to drop some 30 tons of bombs on the Saarland at the height of the Battle of France, in the belief that this would blunt the German offensive. Four years later, more realistic planners were to drop 400 tons of bombs on a single factory.

British belief in strategic bombing was reinforced by the German blitz against British cities, the best example being the attack on Coventry, the center of the British automotive industry. Out of 450 German aircraft dispatched, 449 dropped 503 long tons (2,240 pounds each) of explosives and 881 incendiary canisters during the night of 14-15 November 1940, killing 380 people, burning down the cathedral, and costing the British war effort the equivalent of 32 days of the city's production. The next month, a special committee, analyzing the results Bomber Command had achieved by then, discerned some success against German oil production. This led to a War Cabinet directive, issued on 15 January 1941, to destroy the 17 major oil plants in Germany.

Bomber Command went to work, and soon maps were being carefully inked in showing how German refineries were being flattened. According to reports from the aircrews doing the job, supported by a few target photographs, the targets were being blasted according to plan.

Shortly before, on 16 November 1940, a Photographic Reconnaissance Flight was formed. Just after Christmas, certain officers of the flight unofficially showed their slim collection of photographs to David Bensusan-Butt, the private secretary to Churchill's Chief Scientist, F. A. Lindemann (later Lord Cherwell). Cherwell told his secretary to analyze the photographs statistically. It took him until August 1941.

His report astounded Bomber Command's chiefs, who although they had earlier seen the photographs, had been unable to bring themselves to believe the evidence of their cameras. Of all aircraft recorded to have attacked their targets (by no means all of those dispatched), only one-third had in fact bombed within five miles; while against well-defended targets, such as the Ruhr industrial cities, less than a tenth of the crews put their bombs within five miles, the average bomb missing by some 13 miles. It was now all too clear that German claims were true—British bombing was doing negligible damage. Despite crew reports such as that made regarding the 10-11 November 1940 attack on Ruhland, near Dresden, of "great fires giving off dense clouds of black smoke," German claims that no bombs had fallen on the target or near it, were considerably closer to the truth.

There were, of course, a number of perfectly good reasons for this state of affairs. At the beginning of the war, the Royal Air Force had intended to fly over Germany in formation, as the USAAF was later to do. The bombers, equipped with power-driven turrets, were expected to be able to defend themselves against fighters, partly because of a mistaken belief that a bomber crossing the sights of a fighter would be moving at so high a relative speed that the fighter would not be able to bring its guns to bear, British fighters then (and later) were too short-legged to be able to provide escorts for any distance.

Within the first month of war, the Royal Air Force found that aircraft venturing over German territory in daylight without fighter escort suffered prohibitive losses. The situation was worsened by the fact that many of the British bombers were slow and had low ceilings. The Wellington cruised at 130 knots, the Hampden at 140, and the Whitley, which stayed in combat service for at least two years, had a cruising speed of less than 100 miles an hour. The Manchester had trouble climbing over 10,000 feet, and the Stirling stuck at 15,000. Long before the first winter of the war was over, the Royal Air Force was forced to admit that its bombers were simply incapable of operating in hostile air in daylight. As a result, operations over Germany during the "phoney war" period, when only leaflets were dropped, were all done at night. After France fell, of course, any possibility of fighter escort completely disappeared. Bomber Command had no choice but to follow a policy of night bombing if it wished to do any bombing at all.

The Royal Air Force, unfortunately, like every other air force of the day, had not been trained to operate at night. Night flying was more a tour de force than a serious job. Taking off and landing was bad enough. Navigating turned out to be all but impossible.

The prewar RAF had some highly skilled navigators, but they were not taken very seriously except in Coastal Command. Observers were often air gunners who had been taught the rudiments of navigation, and whose primary job was to observe the fall of artillery shells. The Royal Canadian Air Force, which was to send more than 40 squadrons overseas, entered the war without a single full-time observer.

The tools of air navigation had scarcely changed since 1918. The prime navigation aid was map-reading — "pilotage" in American terms. The most sophisticated instrument was the drift sight. The standard method of navigation was to carry a dead reckoning plot of airspeeds and headings flown, apply the meteorological winds forecast for the route, and rely mostly on pinpoints (ground positions obtained by map-reading) plus occasional drift readings obtained either by the drift-sight or by the rear gunner for en route information. Some use was made of radio. Between the wars the chief method of navigating commercial aircraft was to use ground-based direction-finding, where the airborne radio operator transmitted a long dash, and Adcock stations on the ground took bearings on the aircraft and retransmitted the bearings to the aircraft. The airborne radio operator could also take bearings on the ground stations by means of his own direction finder (DF) loop. The sample navigation log, published in 1941 as part of Air Publication 1234, the RAF Manual of Air Navigation, made use of both these techniques.

Unfortunately, the ground-direction-finding technique was extremely dangerous, since it advertised the aircraft's position to

the German defenders. DF bearings were highly inaccurate, suffering from crude equipment, compass errors, and coastal refraction. Both techniques proved worthless for navigation outbound, although until the end of the war both were used for bombing on the return trip.

Dead reckoning using the meteorological winds was inaccurate, since the average error in the estimation of the wind was some 20 knots, which would cause a 100-mile error in five hours. Correcting it by observing the drift was difficult at night, the only effective method being to throw out flame-floats and take bearings on the light with the rear turret. This was of some help over the sea, although it attracted fighters. After the first few years, the bombers began flying in cloud cover to avoid the rapidly improving skills of the German night fighters, and soon, even this minor piece of navigational information was denied.

Some attempt was made to stress celestial navigation — "astro" as it was called in the RAF. Here again, the path was full of stumbling blocks. The RAF had become seriously interested in celestial navigation only in 1938, and many of the flights over Germany during the first years were made by aircraft that carried neither sextants nor men capable of using them.

Effective celestial navigation, moreover, cannot be learned overnight; it requires years of practice. Even experienced sea captains occasionally add when they should subtract, or take a value from the wrong page of the Air Almanac. Working under cramped conditions, on a tiny chart-table in a poor light, the hurried navigator could not be expected to obtain optimum results in his calculations. Even if he had, the sights he took had an average error of some seven miles, according to Bomber Command figures collected later in the war. The process took a long time, 17 minutes for a fix, since pre-computation had not yet been thought of.

Successful sextant sights require a steady platform, which meant that gunners had to stop swinging their turrets during observations. They were extremely reluctant to do so, since a constant search was imperative in the fighter-infested German skies. This pressured the navigators into taking the bare minimum of sights, and to hurry the ones they did take, with a resultant reduction in accuracy.

The navigators also had a few cards stacked against them that they did not even know about. Phenomena such as jet streams were still unknown, and when they found 100-knot winds, the navigators would not believe them, and would use instead a more "common sense" wind, which would get them lost. Compasses, airspeed indicators, and altimeters were often inaccurate. Maps were often out-of-date. And finally, the Germans camouflaged well their most attractive targets.

Then, as now, navigation required calm, precise work, with every calculation checked, together with a considerable amount of judgment, which still takes years to acquire. Usually, this demanding task was the duty of a man in his early twenties, with ten years of education, who had first flown perhaps 18 months before, and who, within the course of any hour of a mission, had been badly frightened. He was seldom experienced, since the average crew lasted only 14 trips. Records, gathered in the last ten years, of the results of professional commercial transports, shown that not even these veterans are immune from blunders. The wartime navigators were naturally far more vulnerable to mistakes.

Navigation in the target area, leading to the bombing run, had to be done by map reading. This also is a difficult art, especially when one's position is uncertain, owing to the human tendency to make the features on the ground fit one's preconceived idea of where one ought to be. At night, except in bright moonlight, accurate visual checks were almost impossible, and the RAF soon stopped operating in bright moonlight because of heavy losses inflicted by German night fighters. Before long, the RAF's top navigators were teaching their students that the only reliable map-reading feature was water. In bad weather, not even that was visible.

The actual bombing was to be done by sighting on the target through a visual bombsight. This in turn required that the target be identified, a task difficult enough in broad daylight over unfamiliar terrain. To identify a small target at night over blacked-out country proved all too often to be completely impossible; what the crews often did was to drop on a fire. If the general target area was obscured, the crews would usually drop their bombs "blind" at their Estimated Time of Arrival. Needless to say, they seldom hit their targets. Some of the bombs, indeed, landed in the wrong country.

Being human, however, the navigators were reluctant to admit that they did not know where their bombs had gone. The pilots were equally reluctant to admit that they had not recognized the target area either. Target photographs taken by the light of a single flare are usually featureless and hard to interpret. The reports went up to Headquarters that the targets had been bombed as ordered.

Although it was not realized at the time, nor for a long time afterwards, the success of the Luftwaffe fighters in making daylight raids prohibitively expensive for the British was a major German victory. It is even possible that the fact that British bombers could do nothing more than mount nuisance raids — which cost the British more than the Germans — may have encouraged Hitler to attack Russia. He obviously had little to fear on the Western front.

For some six months, Lindemann studied his secretary's report, which told him that, in effect, Bomber Command was scattering bombs at random over Germany, most of them exploding in farmers' fields. Two of his colleagues, Professer P. M. S. Blackett, the Chief of Operational Research at the time, and Professor Zukerman, told him that the bombing offensive was useless. Blackett estimated that a ton of bombs would cause 0.2 deaths, and a proportionate loss in production. To deliver 40 tons would cost about six British aircrew dead or captured, and an aircraft; eight dead German civilians were scarcely a reasonable trade-off. Lindemann, undeterred, analyzed the German attacks on such cities as Hull and Coventry, and wrote a report in which he stated that an area-bombing attack could break the spirit of the German population, provided that it was aimed at the working class areas of 58 German towns, each having a population of over 100,000. He estimated that each 40 tons of bombs (a bomber's loads during its lifetime) would destroy 800 to 1,600 houses and "turn 4,000-8,000 people out of house and home." This would make a third of the whole German population homeless in the next 15 months.

This report became the center of a controversy which has been reported by C. P. Snow in his book **Science and Government**, derived from his Godkin lectures given at Harvard in 1960. Snow blasts Lindemann's proposal, which necessarily called for an area-bombing attack on the houses of the civilian population, as a cold-blooded example of pure frightfulness, coupled with mathematical irresponsibility and self-delusion. The barbarism was clear from a minute written by the Chief of Air Staff, who wrote, in February 1942, "Ref. the new bombing directive; I suppose it is clear that the aiming points are to be the built-up areas, not for instance the dockyards or aircraft factories." The mathematical irresponsibility became apparent when the report was given to Professor Blackett and Sir Henry Tizard for comment. Tizard estimated that Lindemann's estimate was five times too high. Snow says that the report of the Strategic Bombing Survey, made after the war, concluded that the estimate had been ten times too high.

Blackett based his conclusion partly on the fact that German bombs had killed 0.8 persons per ton dropped. Knowing that the

German bombs had been proven by experiment to be about twice as lethal as British bombs, a British bomb would therefore kill about 0.4 persons. The rest of his argument centered around navigation.

The Germans used an automatic dead reckoning computer (Kurskoppler, course computer) and two different ground-based fixing and guidance aids called X-Gerat (X-Gear) and Y-Gerat (Y-Gear). Y-Gerat was virtually the same as the British Oboe, and very like today's Distance Measuring Equipment (DME), in that a transceiver on board the aircraft echoed a ground-oriented pulse, which informed the ground station the distance of the craft from the station. Readings from two stations gave an excellent fix, which was relayed to the aircraft, or was used to allow the ground station actually to control the aircraft. The nearest British equivalent, "Gee," was installed in very few planes, and Blackett knew that over enemy territory it could easily be jammed and made useless. He therefore came to the conclusion that German navigation was at least twice as good as British; this differential would cut German losses to 0.2 deaths per ton of bombs dropped. His conclusion was that bombing Germany would be a waste of time, money, and blood, and Great Britain's aircraft resources would be much better employed on antisubmarine patrols.

Keeping in mind that Lindemann had set a time limit of 15 months on his endeavor, Blackett and Tizard were absolutely right — the bombing effort over the whole period was futile. The Battle of the Atlantic was very nearly lost in the dark winter of 1942-43 and the frightful spring that followed it. British naval historians considered that the war was almost lost for the lack of two squadrons of very long range aircraft; 24 Lancasters would have filled the bill. Twenty-four aircraft was a common night's loss, during a raid in which the bombs usually plowed farmers fields. There is no doubt that the decision was wildly wrong and nearly catastrophic.

The matter does not end there, however, and it warrants more examination. First of all, it must be emphasized that both the plan and the objections to it — although Lindemann hardly mentioned it — revolved about one main point, navigation. No matter how poor British bombs were with their 25% ratio of explosives to total weight, they were far from useless. Furthermore, 40% explosive and 80% explosive bombs were rapidly being developed and quickly put into production. The 4,000-pound "blockbuster" light-case bomb was available after July 1942.

Second half of BOMBER NAVIGATION to be in Spring Issue

Mr Emmott, born in Victoria, British Columbia, served in the RCAF from 1937 to 1964. He navigated Halifax bombers over Germany during WW II, and devoted the last 10 years of service to the development of navigational instruments. Since 1966, he has been employed by Litton Systems (Canada) Limited.

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GUNSHIP

Captain Benjamin C. PITTMAN
HQ USAFA/CWIN
USAF Academy, CO

Time: 2000 hours
"Pilot, B.C., I'm tracking Gamma Ray's beacon."
"Rog, B.C., Gamma Ray, this is Spectre 50. We're tracking your position—are there any threats to the Gunship in your area?"
"Negative, Spectre 50. We've sighted no Triple A or small arms, but we are receiving heavy fire from a tank located approximately 500 meters east of our position. We need immediate fire support."
"Copy, Gamma Ray, we'll lay rounds down ASAP."
"Pilot, FCO, TV has acquired the tank and is tracking tight. Number six gun is selected—automatic mode of fire is set. FCO's ready to fire."
"Pilot, Nav, you're cleared to fire."
"Rog, Nav, pilot's in the HUD —arm the gun."
"Pilot, Engineer, number six gun is armed."
"Round away!"
"Pilot, FCO, direct hit—two secondaries!"
"Spectre 50, Gamma Ray, the threat is silenced. Thanks for a job well done."
Time: 2005 hours

Ho Chi Minh Trail 1970—right? Not quite! The preceding transmissions were taped during a troops-in-contact training mission flown by an AC-130H gunship crew from the 1st Special Operations Wing, Hurlburt Field, Florida.

Yes, Spectre lives, but now the gunships haunt the gray skies of the Florida panhandle, casting bright flashes at targets some 8,000 feet below. Only now the targets are not enemy trucks or tanks, but cold empty hulks with but one purpose—to train Spectre and her crews. The tradition, capabilities, and future employment of the AC-130H Side-Firing Gunship make it as fascinating as any aircraft in the inventory. If you're interested in hearing about a legend—read on!

Colonel Ronald W. Terry, a former Project Branch Chief with the Aeronautical Systems Division (Air Force Systems Command), has been called the father of the gunship program. He theorized that a slow-moving aircraft with guns mounted on the left side could deliver tremendous fire power with amazing accuracy if the weapons could be aligned with a common point on the ground—the target. The problem was solved by flying the gunship in a left-hand orbit while maintaining a constant bank angle and airspeed. Gunship pilots call this procedure "flying geometry." The theory worked, and several transport aircraft were modified to fly the mission. The AC-47, AC-119G, and AC-119K equipped with 7.62 millimeter miniguns and 20 millimeter automatic guns (in the AC-119K only) proved highly successful in Southeast Asia and provoked accusations from the North Vietnamese that we were violating the Geneva Convention by employing a new "death ray!"

Gunship improvements continued to meet the needs of the conflict. The AC-130A model, equipped with 7.62mm, 20mm, and 40mm weapons, was designed as a truck killer to halt enemy support lines through the jungles of Laos. The AC-130H, today's active-duty Air Force Spectre, substituted a 105mm World War II Howitzer cannon for one of the 40s to combat tanks and heavily fortified structures. During Spectre's first night on the Ho Chi Minh Trail, over 200 truck kills were recorded and by the end of hostilities, over 20,000 gunship victories had been logged. But enough of the gunship combat record; military historians can provide much more chilling accounts. Hopefully, all you navs and EWOs are more interested in how Spectre works its magic and how you might function as part of a gunship crew. But first, let me preface the navigator's role by explaining just how the pilots contribute to the mission.

As previously mentioned, the pilot's primary mission is to "fly geometry." A new piece of equipment, the Heads Up Display (HUD), has been added to assist in target acquisition and in solving the geometry problem. Located just inside the aircraft commander's left windscreen, the HUD establishes firing parameters as the pilot aligns target symbology while maintaining proper flight characteristics. The copilot assists the pilot by monitoring bank angles and airspeed, airborne search radar, and repeater electronic countermeasures equipment. The pilots are backed up by the flight engineer who operates the electrical system, regulates fuel management, and monitors engine gauges.

Moving aft on the flight deck we arrive at the hub of each gunship mission—the navigators. Facing right and seated in tandem, the table navigator and the fire control officer (FCO) are key elements, no matter what the scenario might include. Equipped with LORAN and an Inertial Navigation System, the table navigator's duties include: assimilating mission data, enroute navigation, positioning the aircraft in the target area, coordinating the mission plan of attack, target verification, and clearing the pilot to fire. Additionally, during troops-in-contact, convoy escort, and search and rescue missions, the table navigator maintains radio contact with ground forces in order to effectively plot enemy locations, direct fire support, and determine new target locations.

Once in the target area the responsibility for ordnance delivery rests with the FCO. You GIBs might be interested in knowing that the FCO logs Weapons System Officer time and carries a 1585F specialty code. The equipment is designed for target acquisition, target tracking display, weapon selection and control, and post-impact firing corrections (tweaks). The AN/ASN-91 Tactical Computer is the heart of the fire control system and is operated by the FCO to integrate target information from the sensor operator: the Low Light Level Television operator (the TV), the Infrared Operator (the IR), and the Electronic Warfare Officer or the Black Crow (the BC). The TV and IR have video monitors with target acquisition and tracking capability. The TV can operate in either moonlight or darkness with the aid of a laser illuminator or searchlight, and the IR can operate in any light. The FCO has both an 8 inch and 14 inch monitor to view the sensor presentations, which closely resemble that of a black-and-white television set. The sensor tracking the target is usually selected for viewing on the 14 inch monitor so that post-impact firing corrections can be made more accurately.

But let's not leave out the third, and by no means the least important, navigator on the crew—the EWO or Black Crow. Although much of the BC's work is confidential, we can relate the primary duties of threat warning and providing evasive tactics. Additionally, the EWO can, as we saw in the opening scenario, track beacons held by friendly forces. The primary sensor, the ASD-5, is used to gather electronic emissions. In Southeast Asia, the BC proved invaluable by providing over 80% of the initial target acquisitions.

Before tying the whole mission together, let's round out the rest of the 14-man gunship crew—all are essential to the mission. The scanner-observer provides another set of eyes for monitoring engine performance, scanning for ground-to-air threats, and handling gunnery duties when required. The weapons mechanics provide the gunship fire power and assist the FCO with gun settings and ballistic integration into the tactical computer. The illuminator operator is positioned on the aft cargo ramp behind a newly installed bubble and expends flares and searches for AAA or missile threats.

Now that we've briefly covered each crew position, here's how a typical Spectre mission develops. Once in the designated area and radio contact is made with ground forces, targets are plotted by the table nav and fire control officer using a 1:50,000 meter chart. The FCO then directs the sensor operators (TV, IR, and BC) into the target area while the pilots maintain an orbit in the vicinity of the friendly forces. Once a sensor identifies a target, the FCO makes that sensor the primary firing sensor and selects it for viewing on his 14 inch monitor. With the primary sensor tracking, the pilot receives guidance signals from that sensor and sets up an orbit around the target. The FCO then programs the tactical computer and selects the appropriate weapon. For example, if the target is a troop concentration, the 20mm probably will be selected; if it's a tank, the 105mm cannon is the only gun that will do the job. When the primary sensor is tracking the target and the proper weapon is selected and armed, the table nav clears the pilot to fire. The pilot then flies the aircraft so that the primary aimline and computed impact point are superimposed in the HUD. Once accomplished, the pilot depresses the trigger and fires a round. Round impact is monitored by the FCO, TV, and IR for miss distance. Then comes the critical action. A miss call is made by the primary sensor as viewed on the monitor. Then it is verified by the FCO who enters the proper corrections into the tactical computer. If the FCO has evaluated the ballistic wind and gun error information correctly, a direct hit will occur within a few rounds. This procedure is called "tweaking" the guns and it's what makes the FCO's job so critical. In a combat environment, especially in a slow-moving aircraft, the number one objective is to quickly identify the target and get rounds down. The more accurately and quickly the Fire Control Officer completes his work, the more aircrew survivability is enhanced.

Now that was a "quick and dirty" profile—be assured that all AC-130 missions are not so simple. New scenarios are continuously being developed, but for now the Spectre package includes: troops-in-contact, close air support, convoy escort, armed reconnaissance, armed interdiction, perimeter defense, and search-and-rescue missions. The gunship is also working with fighter aircraft for laser-guided-bomb delivery. For future weapons system improvement, an air-to-air refueling capability could be added. That sounds like a lot, but it clearly points out the present and future value of the gunship. Certainly speed and operating altitude limit the environments in which the AC-130 can operate, but the SS Mayaquez rescue proved that there are missions tailor-made for the gunship. And for those of you who might question the accuracy of Spectre—well, if you can knock in a wedge shot from 50 yards, serve an ace to the corner everytime, or make the eight ball on the break consistently, you might be able to compete. And that's no Bravo Sierra!

That pretty much wraps it up for Spectre, 1978. Hope you're as convinced as I am that the gunship is, and will remain, a formidable weapon system. Believe me, being a part of the only Special Operations Wing and flying a legendary aircraft makes our assignment one of the finest around. Navs, remember Spectre and Hurlburt Field, Florida when you complete your next Air Force Form 90! You, too, could feel the thrill of seeing the "kill!"

Capt Pittman entered the Air Force in 1968 via ROTC after graduating from Clemson University. Following UNT and NBT, he was assigned to the B-52H at Wurtsmith AFB. He completed two Arc Light tours in SEA before assignment to Blytheville AFB and then Hurlburt Field. Capt Pittman presently is an instructor at the USAF Academy.

EQUAL TIME POINT

Captain Jay A. WEISS
314 TRW/DOO
Little Rock AFB, AR

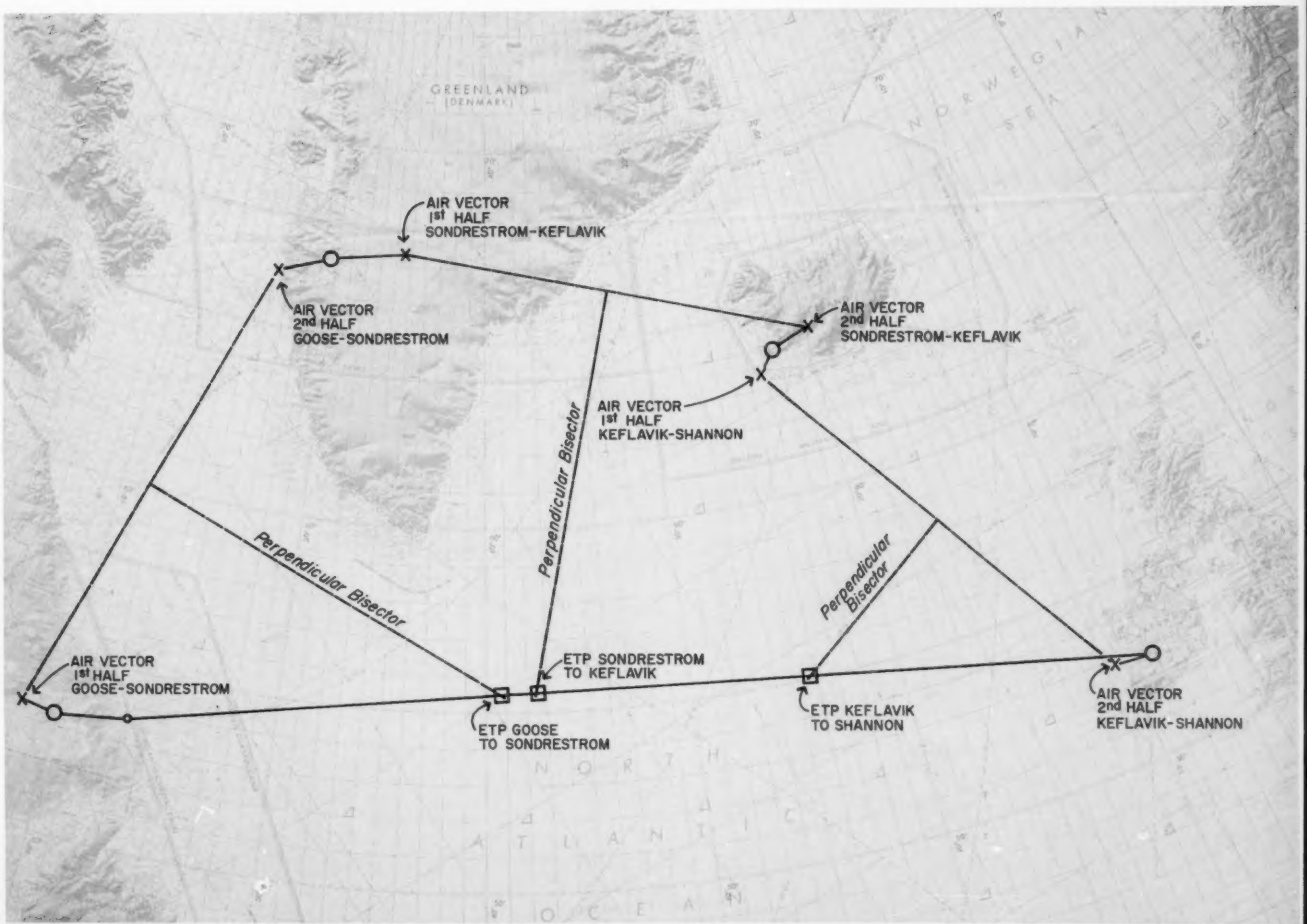
Air Force navigators have used a number of methods to determine whether to continue a flight or return to departure base when difficulties are encountered. Among these methods are point of no return, point of safe return, and equal time point (ETP). Equal time point, a computation presently in vogue, is a point at which time to continue to the first suitable airfield equals time to return to the last suitable airfield. AFM 51-40 gives one method of determining this point:

$$\frac{\text{TOTAL DISTANCE}}{\text{GSr} + \text{GSc}} = \frac{\text{ETP (Miles from last suitable)}}{\text{GSr}}$$

GSr = Groundspeed to return

GSc = Groundspeed to continue

This method, while ideally suited for flights between island destinations with no alternates along the intended flight path, does not consider suitable diversion fields in excess of 50 nm from flight path. For example, consider a flight from Goose AB, Labrador, to RAF Mildenhall, England. Two possible alternate fields exist (Sondrestrom, Greenland; and Keflavik, Iceland), in addition to a last suitable field of Goose and a



EXAMPLE:

FIELDS	DIST	NO WIND TIME	½ NO WIND TIME
Goose to Sondrestrom	875	2+55	1+27.5
Sondrestrom to Keflavik	720	2+24	1+12
Keflavik to Shannon	800	2+40	1+20

	WIND FACTORS	TIME	AIR VECTORS
Goose — Sondrestrom WF1	280/40	1+27.5	280/58
WF2	250/60	1+27.5	250/88
Sondrestrom to Keflavik WF1	080/100	1+12	080/120
WF2	070/60	1+12	070/72
Keflavik to Shannon WF1	220/30	1+20	220/40
WF2	280/50	1+20	280/66

first suitable field of Shannon, Ireland. AFM 51-40 does not provide a computation for the two alternate choices of Sondrestrom and Keflavik. Instead, an alternate solution involving air vectors can give equal time points considering all four fields. I'll give a general overview of the method, followed by a specific solution.

Overview:

1. Measure distances between successive alternate airfields.
2. Spin true airspeed (I used 300 k) against these distances to get a no-wind time.
3. Obtain wind factors from weather charts and plot air vectors based on half the no-wind time between successive alternate airfields. (Use two corresponding wind factors between each base.)
4. Connect the air vectors between fields and construct a perpendicular bisector for each connecting line.
5. The points where perpendicular bisectors cross course line are equal time points.

Draw the above air vectors out of respective fields. For example, the first air vector from Goose to Sondrestrom (280/58) is plotted out of Goose, while the second (250/88) is plotted out of Sondrestrom. Then connect the two air vectors and draw a perpendicular bisector on the connecting line. The ETP between Goose and Sondrestrom is located where the perpendicular bisector crosses course line between Goose and Shannon (see illustration). Repeat the above process for the leg from Sondrestrom to Keflavik, and again from Keflavik to Shannon.

You now have three equal time points, indicating three different points at which times between two alternate fields are equal. Note that if TAS changes, the equal time points will change also, so you may want to construct this graph (or make the AFM 51-40 computation) with expected TAS after loss of an engine.

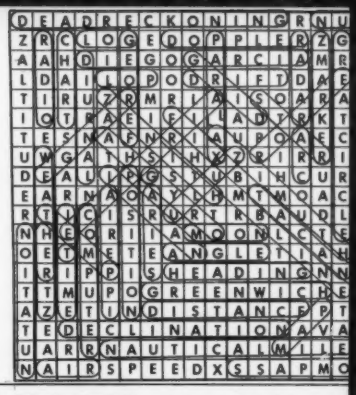
While I do not claim credit for inventing this method of ETP calculation, I do find it useful when more than two fields are available for emergency landings on an overwater flight. After plotting this solution I have a visual depiction of available alternates and respective wind vectors, as well as ETP locations, for the entire route of flight.

Capt Weiss graduated from the University of Kansas in 1967. He completed UNT in 1968, was assigned to the C-130, and spent a tour in the Philippines and Vietnam where he earned the DFC and several Air Medals. He has 5,700 hours of navigator time plus 2,000 hours of civilian pilot time. Capt Weiss now is assigned to the 314 TAW, Little Rock AFB.

FROM THE EDITOR

The twenty-fifth anniversary of THE NAVIGATOR is an appropriate time to congratulate those who have practiced our craft in the great tradition of Air Force aviation. We also give thanks to our many loyal readers and contributors. THE NAVIGATOR will continue to strive to meet your professional information needs.

WORDGRAM SOLUTION FROM PAGE 19



The many topics of navigation covered in the past 25 years make THE NAVIGATOR an invaluable reference. We are always happy to respond to the inquiries we receive from both headquarters and operating units. To be even more useful we have compiled an index of all articles published from 1953 to the present. We invite requests for the index from official users, on your organizational letterhead. The index should be useful to those units with a library of back issues.

Also, we are glad to report on correspondence from other publications of interest to Air Force navigators. The Editor of the AIR UNIVERSITY REVIEW has asked us to remind our readers that, as the professional journal of the Air Force, the REVIEW is interested in manuscripts from all facets of Air Force life. It strikes us that navigators are often at a particularly good vantage point to comment thoughtfully on matters affecting our mission. We encourage our readers to consider writing for the AIR UNIVERSITY REVIEW. Also, we commend to you an excellent journal of aviation history — THE AEROSPACE HISTORIAN, published by Kansas State University. This fine magazine was the source of a well-received story in our last issue — "Anyone Can Navigate" (Summer 1978, page 24-29). Due to an unavoidable delay we were unable to print the following credit:

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TO THE EDITOR

Dear Editor,

I was very pleased with the nav formulas article in the Winter 1977 edition of THE NAVIGATOR. After over four years of operational experience with various computers, I can attest to the noticeable savings in time and the reduction in errors these handheld wonders can produce. While the current generation of programmable calculators has a very large program memory, all too often the program is just a few steps too long. Therefore, I would like to offer the following short cuts and additional formulas. (When possible I have retained Captain Hairston's abbreviations and definitions.)

FLIGHT PLANNING

Definitions:

TC = True Course
TH = True Heading
GS = Groundspeed
TAS = True Airspeed
W/V = Wind
W = Wind Direction
V = Wind Velocity
DCA = Drift Correction Angle
TW = Tail Wind Component
CW = Crosswind Component

$DCA = SIN^{-1} [(V/TAS) SIN (W-TC)]$

$GS = TAS COS (DCA) - V COS (W-TC)$

$TW = V COS (W-TH)$

$CW = V SIN (W-TH)$

CELESTIAL PRECOMPUTATIONS

Once the azimuth angle (Z) has been determined by computation using Captain Hairston's formula, the ambiguity caused by Lat and LHA can be resolved by the following:

$ZN = Z$ if $SIN (LHA) < 0$

$ZN = 360 - Z$ if $SIN (LHA) \geq 0$

MOTIONS

The formula for combined 1 minute motion can be separated as follows:

Motion of Body = 15 COS LAT SIN ZN

Motion of Observer = (GS/60) COS (TC-ZN)

These quantities, whether combined or used separately, must be added algebraically to the Ho and subtracted from the Hc.

GREAT CIRCLE PLANNING GIVEN

L_1 = Departure Latitude N+W=+
L_2 = Destination Latitude S+E=-
λ_1 = Departure Longitude
λ_2 = Destination Longitude
L_i = Intermediate Latitude
λi = Intermediate Longitude
H_i = Initial True Heading
D = Dist in Nautical Miles
H = Heading Angle

$$D = 60 \cos^{-1} [\sin L_1 \sin L_2 + \cos L_1 \cos L_2 \cos (\lambda_2 - \lambda_1)]$$

$$H = \cos^{-1} \left[\frac{\sin L_2 - \sin L_1 \cos (D/60)}{\sin (D/60) \cos L_1} \right]$$

$H_i = H$ if $\sin (\lambda_2 - \lambda_1) < 0$
$= 360 - H$ if $\sin (\lambda_2 - \lambda_1) \geq 0$

Given (L_1, λ_1), (L_2, λ_2) and λ_i the following formula computes the latitude of L_i where λ_i intersects the great circle defined by (L_1, λ_1) and (L_2, λ_2).

$$L_i = \tan^{-1} \left[\frac{\tan L_2 \sin (\lambda_i - \lambda_1) - \tan L_1 \sin (\lambda_i - \lambda_2)}{\sin (\lambda_2 - \lambda_1)} \right]$$

(This formula can be very useful when matching charts of different projections or scales.)

RHUMB LINE PLANNING

L_1 Dept Lat
L_2 Dest Lat
λ_1 Dept Long
λ_2 Dest Long
C = Rhumb Line True Course
D = Rhumb Line Distance
π = Pi (3.14159.....)

$$C = \tan^{-1} \left[\frac{\pi (\lambda_1 - \lambda_2)}{180 \ln \tan (45 + \frac{1}{2} L_2) - \ln \tan (45 + \frac{1}{2} L_1)} \right]$$

$D = 60 (\lambda_2 - \lambda_1) \cos L_i$ if $C = 0$

$$\frac{60 (L_2 - L_1)}{\cos C} \text{ if } C = 0$$

TURN PERFORMANCE

Definitions:
BANK = Bank angle in degrees
DIAM = Turn diameter in nm
TAS = True airspeed in knots
T = Time in minutes to complete 360° turn

$$\text{DIAM} = \frac{\text{TAS}^2}{34208 \text{ TAN (BANK)}} \qquad t = \frac{.0055 \text{ TAS}}{\text{TAN (BANK)}}$$

In addition to these formulas I have written a number of programs applicable to navigation in general and SAC bombing/navigation in particular. While much too long to be included in this article, each program is written for the HP67/97 and/or TI 59, including complete documentation. They are not for sale, but I will make them available to active duty navigators. Those of special interest to SAC navigators are so indicated. Each area has one or more related programs and a brief list is:

Celestial Precompe
Celestial Motions
GHA Aries
GHA Sun
Star Identification
Star Selection
Flight Planning
Flight Verification
Dead Reckoning (G.C. and Rhumb Line)
Great Circle Planning
Rhumb Line Planning
Time Sunrise/Sunset/Twilight
Sun Lines/Noon Time Fixes
Turn/Climb Performance

CRB/Mapmatch Alternate Bombing, In-flight And Planning (SAC)
Peak/Flat and Rolling Calibrations (B-52—SAC)
Celestial (SAC)
Flight Planning (SAC)
SRAM Vector Analysis (SAC)
SRAM FIRT OCTAL to Decimal Conversion (SAC)
Timing Tables (SAC)
Bombing Analysis and Vectoring (SAC)
Target/Offset Correction Computations (SAC)

For more information, contact me at the address shown or at AUTOVON 352-5410.

Captain Charles M. Floyd
325 BMS
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